Sky and TELESCOPE

In This Issue:

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Radar antenna and the moon

Sky and TELESCOPE

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CHARLES A. FEDERER, JR., *Editor*; HELEN S. FEDERER, *Managing Editor*

THE C.D.A.L. COMPLETES ITS ACTIVITIES

THE Committee for the Distribution of Astronomical Literature (under the American Astronomical Society), in collaboration with the Office of War Information and the U. S. State Department, made sincere efforts during the war to keep astronomers in all parts of the world informed about astronomical news and developments. Astronomical Newsletter No. 36, dated February, 1946, but circulated in March, is the farewell issue of this good Samaritan. The usual channels for its distribution ceased activity before the material for No. 36 was ready. It is therefore issued by the office of the former committee, under the direction of Professor B. J. Bok, of Harvard. Not only to the O.W.I. and the State Department, but also to the contributors and the colleagues abroad who helped so effectively in the world-wide distribution of the Newsletter — especially to those in Great Britain, the U.S.S.R., Sweden, and Switzerland — the committee expresses its thanks and indebtedness.

The farewell issue contains news from Holland and three reviews of topics of current interest. Reports on wartime and postwar astronomical activities in that country are a cheering example for all. Since July, 1945, Dutch astronomers have been publishing a paper similar to the Newsletter but in Dutch for local circulation. A mere listing of the researches abstracted from their first six issues occupies almost two pages. The physics of interstellar space, including studies of the formation of molecules and larger particles, their dimensions and bearing on interstellar absorption and the scattering of light; the space density of massive blue stars and their motions; spectra of Cepheid variables; discovery and photometric analyses of faint variable stars; and solar physics (actively carried on by underground students and colleagues of Dr. M. Minnaert, who was being held hostage by the Germans) are topics pursued not superficially but intensively. Even while imprisoned, Minnaert worked on several projects: the reflection of sunlight from the moon and the atmosphere of Venus, the temperature of cometary nuclei, and the distribution of sunspots over the solar disk.

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COVER: The 100-foot tower of the Evans Signal Laboratory at Bradley Beach, N. J., on which is mounted the antenna used in the radar-moon experiments. The radar shack is directly behind the tower, and an SCR-271 antenna, half the size of the moon antenna, can be seen behind the shack. The antenna at the lower right, which was not used in the Diana project, is an MPG-1 fire-control radar antenna. (See page 3.)

BACK COVER: A portion of the northwestern edge of the moon near first quarter, from a Lick Observatory photograph taken with the 36-inch refractor by J. H. Moore and J. F. Chappell. The reproduction is reduced 10 to 7 from a 7.8 enlargement of the original negative. (See In Focus.)

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PROJECT DIANA

Army Radar Contacts the Moon

By Harold D. Webb

Physicist, Evans Signal Laboratory
Signal Corps Engineering Laboratories, U. S. Army

FOLLOWING the announcement on January 25, 1946, that the Signal Corps experiments were successful in making contact with the moon by radar, the imaginations of news reporters and feature story writers went wild with predictions that space ships would soon be a reality. True, our experiment has shown that it is possible to send radio waves through the atmosphere and ionosphere surrounding the earth, and that thereby it would be possible to make continuous radio contact with rocket ships far out in space. More important, however, the experiment has provided a new means to make studies of the propagation of radio waves through the earth's atmosphere. Further than that, it is now possible to use the moon as a reflecting surface for radio communications transmitted from a point on the earth; these communications can be received approximately 2½ seconds later at almost any point on the half of the earth's surface which is facing the moon.

The idea of sending radio signals to the moon and receiving the reflected signal back on the earth was conceived by Lt. Col. John H. DeWitt, Jr., before he entered the Armed Forces. Colonel DeWitt designed a special directional antenna and transmitter to operate at a frequency of 110 megacycles per second and performed the experiment. Because the equipment used was not sensitive enough to detect the returning signal from the moon, the experiment was not successful. Following V-J Day in August, 1945, Colonel DeWitt revived the moon experiment, calling it the "Diana Project" after the goddess of the moon, making use of special radar equipment designed for and at the Evans Signal Laboratory during the war.

The first echoes were received from the moon at 11:58 a.m. and 12:09 p.m. on January 10th, in the form of audible signals. The calculated time for moonrise was 11:48 a.m., and as will be noted later, the reception times correspond to those when the moon was in the first and second lobes of the receiving antenna pattern. These lobes of maximum sensitivity are centered at points approximately 0.8 and 2.3 degrees above the horizon. Possibly the moon echo was received in the second lobe and the third (at 3.8 degrees) if there was an appreciable refraction due to passage of the radar impulse through the maximum thickness of the earth's atmosphere.

The five men who have done most of the work on the Diana project at the Evans Signal Laboratory are (left to right): Jacob Mofenson, radio engineer; Dr. Harold D. Webb, physicist; Lt. Col. John H. DeWitt, Jr., who originated the project and directed the work; E. King Stodola, chief, Special Development Section; and Herbert Kauffman, radio engineer. Much work was also done on the project by members of the Special Development, Antenna Design, and Mechanical Design sections of the laboratory.

Echoes from the moon have been received near both moonrise and moonset on many occasions since January 10th. The important data and results of several observations are given in the table accompanying this article. It will be noted in all cases that the echoes were received during the time that the moon was in one of the lobes of the antenna pattern. On various occasions, echoes were received at or before moonrise, which the lobe pattern indicates can occur only if the radio beam is refracted by the atmosphere.

Radar gives a method of observation which can be used during almost any type of weather. It seems from radar data that the increase in attenuation due to precipitation is not great for the longer wave lengths that are used in radar.

The system used, however, is seriously affected by external interference, including that from amateur radio, ignition noises, from the sun, and even noise from outer space if such noise exists. When the antenna is pointed toward the sun there is an increase in noise at the receiver output, at times as much as 15 to 20 decibels above the receiver noise. Observations of the moon or other heavenly bodies by radar will, therefore, be seriously limited if the direction toward those bodies is near to that of the sun. The observations made to date have not been accurate enough to detect any noise from the illuminated part of the moon.

Nor has it been possible to measure the distance to the moon more accurately than to the nearest 1,000 miles. Future improvements may lead to radar methods for measuring the moon's distance to the nearest mile, or possibly to the nearest 0.1 mile. Greater antenna gains at higher frequencies may give antenna beams narrow enough to use to study detail in the moon's surface. This possibility requires much more transmitter power than can now be obtained at the higher frequencies.

With increase in antenna gain and transmitter power output, it may be possible to make contact with planets or the sun. It is believed, however, that the sun observation is not feasible because of noise from the sun (the sun's own radio output) and because of the absorption of radio energy by the sun.

The Signal Corps is not planning to try to make contact with heavenly bodies other than the moon.

Astronomical factors involved. The observations that have been made to date have been seriously limited by the fact that the antenna could not be changed in elevation. It is planned to use, in the future, an antenna which can be moved in azimuth and elevation; it will then be possible to observe the moon over long periods and thereby to get more valuable data.

Inasmuch as the antenna that was used in the experiment could be rotated in azimuth only, it was necessary to observe at or near moonrise or moonset. The *amplitude angle* of the moon from true east or west was calculated from data given in the *American Ephemeris and Nautical Almanac.* At moonrise, our antenna, located at 40° 10′.5 north latitude, partakes of a component of the earth's rotational velocity and moves toward the moon at 795 miles per hour times the cosine of the amplitude angle. Because of the very narrow bandwidth of the receiver that was used, it was necessary to take into consideration the change in frequency due to the Doppler effect resulting from this motion.

But there is a second velocity component which must be considered, the change in distance from the earth to the moon due to the moon's motion in an elliptical orbit. From values of the moon's apparent semidiameter listed in the *Ephemeris,* given for each 12 hours throughout the year, it is possible to calculate the rate at which the moon approaches or recedes for this reason. Of particular astronomical interest is the fact that this radial component of the moon's orbital velocity can be measured with considerable precision by the radar methods described in this article.

The relative motion due to the earth's rotation varies between 685 and 795 miles per hour for our latitude, depending on the moon's amplitude angle, and is considered positive when we are approaching at moonrise, negative at moonset. The relative motion caused by the moon's revolution gives velocities ranging from —185 to +185 miles per hour. These two motions may be added algebraically to compute the net motion producing a Doppler shift in the frequency of the received energy. It may be easily shown that for 111.5 megacycles the Doppler frequency change is obtained by multiplying this net motion by 0.333, for the Doppler shift is linear over the range of velocities that is encountered.

Since the distance to the moon is between 221,000 and 253,000 miles, approximately, the time interval between the beginning of the transmitted pulse and the beginning of the returning echo will be between 2.38 and 2.72 seconds, approximately (see Fig. 1). If a type A oscilloscope presentation is used, as in radar, a linear time base, or sweep, from three to five seconds long will be required. This is in contrast to the sweeps of from 625 to 10,000 cycles per second usually used in radar. If a three-second linear time base is spread over six inches on a nine-inch cathode ray tube, a 0.1-second pulse will give a 0.2-inch pulse on the oscilloscope. This is near the minimum requirement for good viewing.

From a consideration of the size of the moon, a minimum pulse duration of 0.0117 second is required to make sure that the maximum echoing area of the moon is used and that the time duration of the returning echo will be equal to that of the transmitted pulse. This is the time required for the radio energy to cover the entire surface of the moon which is toward the earth, plus the time

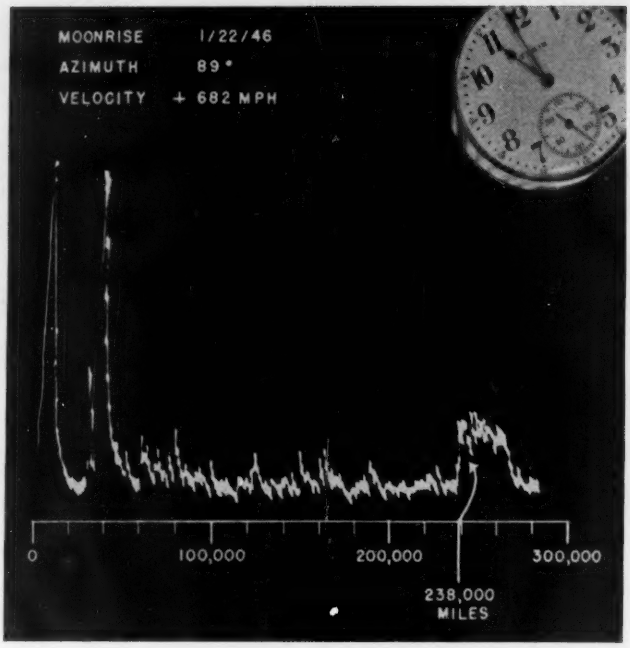


Fig. 1. Photograph of the screen of the 9-inch oscilloscope, taken at 10:59 p.m., January 22, 1946. The calculated time for moonrise was 10:34. The large spikes at the left are produced by the main pulse. Note that the returning echo duration is approximately the same as that of the main pulse.

DATE Jan. 1946	MOON-RISE TIME	DECLI-NATION (°)	AMPLI-TUDE (°)	AZIMUTH FROM NORTH (°)	RADIAL VELOCITY (mph) Earth Rotation	Moon Orbit	Total Vel.	DOPPLER FREQUENCY (cps)	REMARKS
10	1148	+2.4	+3.2	86.8	+782	+69	+851	+284	Several echoes audible only at 1158 and 1209.
11	1218	+8.1	+10.6	79.4	+775	+59	+834	+278	Several echoes audible and visible at 1227 and 1237.
12	1251	+13.5	+17.7	72.3	+750	+42	+792	+264	Several echoes at 1302 and 1311. Some persons present heard echoes at 1251.
13	1328	+18.1	+23.8	66.2	+720	+17	+737	+246	Several echoes at 1328, 1338, and 1347.
16	1604	+23.9	+32.0	58.0	+670	-70	+600	+200	Several echoes at 1606. None later.
21	2134	+6.0	+7.8	82.2	+779	-123	+656	+219	Several echoes 15 decibels above receiver noise up to 45 minutes after moonrise.
22*	2234	+1.0	+1.4	88.6	+785	-103	+682	+227	Trouble with system to 2255. Several echoes after 2256.
27	0229	-17.5	-23.2	113.2	+728	+31	+759	+253	Several echoes about 10 and 20 minutes after moonrise.
	MOONSET								
22	1026	+3.3	+4.3	274.3	-782	-114	-896	-299	Several echoes at 1010, 1014, and 1017.
26	1206	-15.3	-20.2	249.8	-743	+15	-728	-243	Several echoes from 1153 to 1200.
28	1259	-21.6	-28.8	241.2	-695	+72	-623	-208	Several very strong echoes. Times not recorded.
31	1544	-23.3	-30.2	239.8	-687	+107	-580	-193	Echoes at 1528. No others recorded.

*The photograph in Fig. 1 was taken at this observation.

The data for and results of several observations made near times of either moonrise or moonset, during January, 1946, are tabulated above. All times given are Army-Navy time.

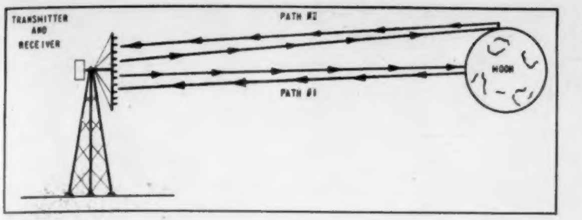


Fig. 2. The minimum usable pulse width is about 0.012 second. Path 1 is about 2,000 miles shorter than path 2, so a "zero width" transmitted pulse returns spread over the period required for 2,000 miles travel.

for the energy to be reflected from the points on the outer edge of the moon through a distance equal to the moon's radius, as is shown by Fig. 2. If a returning echo having rectangular shape is desired, the transmitted pulse duration should be long compared to 0.0117 second, in order to reduce the effect of differences in time required for the return of the signal from different parts of the moon. It appears then that a pulse duration between 0.2 and 0.5 second would be a good choice. Contrast this with the usual radar requirement of 0.1 to 20 microseconds, depending on the type of radar.

Description of the system used. The block diagram of the system used is given in Fig. 3. The transmitter and receiver were designed for another purpose, and chosen for this experiment because they could be easily modified to meet the requirements. It can be seen from the diagram that the transmitted frequency and the frequencies of three of the receiver local oscillators are derived by multiplying the frequency obtained from a crystal-controlled oscillator by the proper amounts. The frequency of the last local oscillator is obtained by multiplying that of a second crystal-controlled oscillator by three. The last frequency conversion results in an intermediate frequency centered at 180 cycles per second. The effective bandwidth of the receiver is made 60 cycles by passing this last intermediate frequency through an audio filter which has a band-pass 60 cycles wide at the half-power points.

As already mentioned, this narrow band-pass required that the receiver be properly adjusted to take into account the Doppler effect frequency shift. Referred to the last mixer, the transmitted frequency is 1,548,600 cycles per second. At moonrise, the crystal controlling the last local oscillator frequency is adjusted to 1,548,600 + F + 180 cycles per second, where F is the Doppler shift. This adjustment is accomplished by placing a signal at F + 180 cycles from an audio signal generator on one set of plates of an auxiliary oscilloscope and the last receiver mixer output on the other set of plates. The crystal frequency is changed by varying the air-gap above the crystal until a stationary circular or elliptical pattern is obtained. The output of the last mixer is then at F + 180 cycles and will not pass through the filter. When a signal is received from the moon, its frequency will be 1,548,600 + F cycles when it reaches the last mixer. The mixer output will then be 180 cycles and will pass through the filter so that it will be seen on the oscilloscope. At moonset, the last local oscillator frequency is adjusted to be 1,548,600 — F —180 cycles per second. A loud-speaker was placed across the last mixer output so that returning signals can also be received audibly.

For reasons already explained, the pulse duration chosen was 0.2 to 0.5 second. The oscilloscope sweep time was made three seconds by using a direct-coupled saw-tooth sweep generator with properly chosen constants. The sweep generator also triggered a direct-coupled multivibrator which was used to generate the keying pulse. This, in turn, was applied to the cathode of one of the multiplier stages of the transmitter by means of a relay. This relay also controlled the operation of the mechanical TR system, which was also operated by relays. The TR system, shown diagrammatically in Fig. 3, was used to match properly the transmitter to the antenna and short out the receiver during transmission, and to match properly the receiver to the antenna and short out the transmitter during reception.

The transmitter used was essentially a CW transmitter which was keyed to transmit 0.2- to 0.5-second pulses of radio frequency energy at 111.5 megacycles. The power delivered to the antenna during the pulse was 4,000 watts. As has been pointed out, the frequency of the transmitter was crystal controlled.

The antenna consisted of two SCR-271 arrays mounted side by side, giving an array eight dipoles high and eight dipoles wide. This antenna was mounted on a 100-foot tower, and is pictured on the front cover of this issue. At moonrise, the antenna looks off the edge of a cliff so that its effective height is about 175 feet. The principal radiated beam is horizontally polarized and is approximately 15 degrees wide in the horizontal plane at the half-power points.

The free-space power gain of the antenna is 250 times that of an isotropic radiator, a gain used on both transmission and reception. Due to ground reflections, the antenna pattern in the vertical plane is much the same as that shown in Fig. 4. There is a 12-decibel increase in overall gain in the center of the main lobe (centered at about 0.8 degrees elevation) if the maximum effect due to ground reflections is obtained. The antenna looks over the ocean during moonrise, and over land during moonset. As reflections are somewhat better over sea water than over rough terrain, the effective antenna gain is probably greater during moonrise than during moonset observations.

A specially designed preamplifier having low noise characteristics was placed ahead of the crystal-controlled receiver, thereby making the operating receiver noise figure approximately eight decibels.

Fundamental radar equations. Some readers may wish to know the reasoning whereby it was determined that the ex-

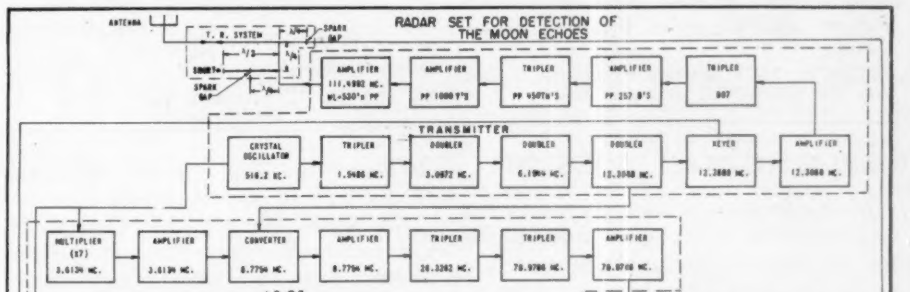


Fig. 3. A block diagram of the radar system used to contact the moon.

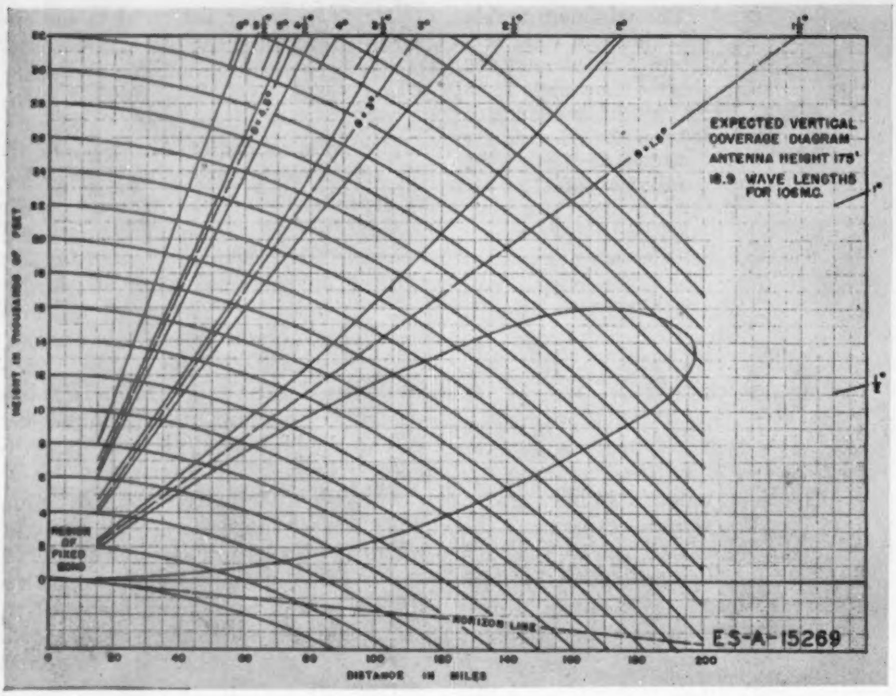


Fig. 4. Theoretically calculated vertical coverage pattern for an SCR-271 antenna 175 feet above the ground operating at 106 megacycles per second. The SCR-271 antenna is eight dipoles high, the same as the antenna used in the moon experiment. The maximum effect due to ground reflections is assumed. Note that the first lobe extends from about 0.6 to 1.2 degrees; the second, from about 1.9 to 2.7 degrees; the third lobe, from about 3.3 to 4.3; and the fourth from about 4.7 to 5.8. No refraction is taken into consideration in this diagram.

periment was possible using the radar principle. The formulas below are well known to those familiar with radar.*

The power that will be received by an object of area **A** at a distance **R** from a transmitter is given by: $\mathbf{P' = PGA/4 (pi)R^2}$, where **P'** is the power in watts received by the object; **P** is the transmitted power in watts; **G** is the power gain of the transmitting antenna with respect to an isotropic radiator. Let us assume that **P** is 4,000 watts; **G** is 1,000 (for an antenna twice the size of an SCR-271 with maximum ground reflections); **A**, the projected area of the moon, is approximately (pi) $\times$ $1{,}080^2$; and **R** is 238,000 miles, the approximate average distance to the moon. **P'** is then computed to be 20.6 watts.

Assuming that the surface of the moon is volcanic rock, non-conducting, with a dielectric constant of 6, theoretical calculations made by Walter McAfee, of Evans Signal Laboratory, show that 0.172 times the power received by the moon will be reflected in all directions. The maximum power from the moon that is available at the input terminals of a radio receiver on the earth, properly matched to the receiving antenna, is $\mathbf{p = P'' a/4 (pi) 238{,}000^2}$, where **P''** is the power reflected by the moon, and **a** is the effective area of the receiving antenna (in square miles, or other appropriate unit). If **g** is the power gain of the receiving antenna with respect to an isotropic radiator, the area of the antenna is $\mathbf{a = gL^2/4(pi)}$, in which **L** is the wave length of the received radio wave. As wave length equals velocity **(v)** divided by frequency **(f)**, $\mathbf{a = gv^2/4(pi)f^2}$, which makes $\mathbf{p = P'' gv^2/16(pi)^2 (238{,}000)^2 f^2 \times 10^{12}}$, where **f** is in megacycles per second.

In accordance with the above, let us assume that **P''** is 0.172 $\times$ 20.6 watts; **g** is the same as **G**, 1,000; **v** is 186,000 miles per second; and **f** is 111.5 megacycles per second. The maximum power from the moon that would be available at the input terminals of the receiver will then be 11.0×10^{-16} watts.

It can be shown that the noise figure of a receiver is $\mathbf{N = E^2/4R/KTB}$, where $\mathbf{E^2/4R}$ is the maximum available signal power at the receiver input terminals, in watts; **E** is the signal voltage available at the antenna terminals for a one-to-one signal-power to noise-power ratio. **KTB** is the maximum available noise power at the receiver input terminals, where **K** is Boltzmann's constant, 1.37×10^{-23} joules per degree Kelvin; **T** is in degrees Kelvin, usually taken as 300° K.; and **B** is the receiver equivalent noise bandwidth, approximately equal to the half-power bandwidth, in cycles per second.

The above equation may be rewritten $\mathbf{E^2/4R = NKTB}$, which gives the power available at the receiver input terminals for a one-to-one signal-power to noise-power ratio at the receiver output terminals. If **N** is assumed to be 10, and **B** is 57 cycles per second, $\mathbf{E^2/4R}$ is 2.34×10^{-18} watts. This compares favorably with the power received from the moon of 11.0×10^{-16} watts, and means that a receiver with the above characteristics will receive this power 26.7 decibels above noise. It was shown therefore to be possible to receive a signal from the moon provided a system could be operated which would be as good as is required by the above assumptions.

* Printing limitations have necessitated changes from the conventional symbols. ED.

SPECTRUM GLORIOSUM

Man's location midway between the smallest units in the microscopic world and the largest units in the macroscopic world has long been known. Now it appears that in an all-embracing spectrum of the vibrations of the universe, with such periods as audible sound, breathing, heartbeats, and the like, man again has a middle position.

This "spectrum gloriosum" has been published in *Electronic Industries* for January, 1946. From the familiar X-rays and light at one end of the gigantic spectrum, the reader is introduced to the periods of vibration of himself and the buildings he lives in, to the cycles of "Old Faithful," volcanoes, comets, and to the extremely long period of the rotation of the galaxy. This last requires on the order of 10^{16} seconds per cycle; the human heartbeat is nearly one second per cycle; million-volt X-rays have 10^{20} cycles per second. Editor Orestes H. Caldwell points out that our position midway between these extremes is probably only temporary, in that our present observing facilities permit us to see about equally far in either direction.

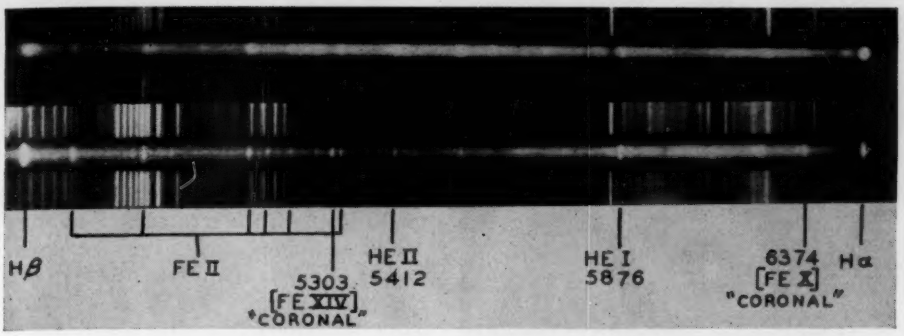
NAVAL AWARD TO McMATH-HULBERT STAFF

Late in February Vice Adm. George F. Hussey, Jr., navy ordnance chief, in a ceremony at Ann Arbor, Mich., presented to Dr. Robert R. McMath and members of the staff of the McMath-Hulbert Observatory the Naval Ordnance Development Award. At the same time, the observatory received an institutional award.

The presentations were made in recognition of important contributions during the war to the development of a navy bombsight, details of which have not yet been revealed. In addition to Dr. McMath, Dr. Leo Goldberg, Dr. Orren C. Mohler, and George H. Malesky received certificates of exceptional service.

A.A.A.S. SECTION D MEETS

On March 29th and 30th, the section on astronomy of the American Association for the Advancement of Science was scheduled to meet in the Municipal Auditorium in St. Louis, Mo., where the general meeting of the association also took place. Among a variety of papers announced in advance were the addresses of Dr. Seth B. Nicholson, of Mount Wilson Observatory, and of Dr. Robert R. McMath, of the McMath-Hulbert Observatory.



Spectra of T Coronae Borealis in the visual region, as photographed by Dr. D. B. McLaughlin at the University of Michigan Observatory. The upper spectrum was taken on February 11th, two days after the discovery of maximum brightness; the lower spectrum was made on February 16th. The comparison lines are from a titanium spark and a neon tube. A light curve of this star may be found on page 16.

The Spectrum of T Cor Bor

WHEN T Coronae Borealis suffered a previous outburst in 1866, the only observations of its spectrum were made visually with great difficulty. Sir William Huggins at that time described the spectrum and mentioned some bright lines whose identification has remained doubtful until now, chiefly because the description of the spectrum did not tally with that of other novae. His description, in the light of spectra taken at the current outburst, now becomes clearer. The bright lines were due to ionized helium and doubly ionized nitrogen. The star has almost exactly duplicated its previous increase to great brilliance.

Most novae just after maximum light have strong bright lines of hydrogen and ionized iron. They do not show neutral helium lines until they have faded three magnitudes or more, and ionized helium does not show until they have declined another magnitude or two. On February 10th and 11th, one and two days after the discovery of the outburst by Yerkes Observatory, the star's spectrum (taken at Ann Arbor) showed lines of neutral helium conspicuously, and ionized helium strengthened greatly from February 10th to the 11th. Ionized iron, on the other hand, was rather weak.

All this indicates higher temperature, capable of ionizing and exciting helium, while iron is more than once-ionized, making the lines of the singly ionized atom weak. Hydrogen bright lines, as in all novae, were strong, with dark lines on their edges of shorter wave length. T Coronae was at a higher temperature than most novae at the same stage of the light curve, and getting hotter. This probably means that, as the eruption continued, outer cooler layers of gas were shed from the star, uncovering the hotter layers below. In the hazy absorptions on the violet sides of the hydrogen and the helium emission lines, there were slightly stronger regions of absorption — three components probably, with velocities of —1,200, —800, and —500 kilometers per second — but these show only on plates of the best contrast. (The 500-kilometer component strengthened from February 10th to the 11th.)

After a cloudy interval of three nights (at Ann Arbor) there was radical change by February 15-17. The emission bands had narrowed to less than half their previous width and were very definitely edged. Hydrogen and helium emissions had conspicuous *narrow* and well-defined absorption lines to the violet at about —350 kilometers per second. Certain helium lines were especially strong, such as the "diffuse triplets" (4026, 4472) and the lines 3965 and 3889. These are the lines that are strong in outer atmospheric shells of stars. Line 4686 of ionized helium had strengthened greatly, almost equaling the hydrogen-beta line. In the visual region, the coronal emissions at 5303 and 6374 had appeared conspicuously; they were narrow as were all the other emissions.

February 21st followed another cloudy interval of three nights, but there was not a great deal of change. However, although at first sight the spectrum looked about the same, the emissions had narrowed to only about one half (or a bit more) their width on February 16th. The absorptions at —350 kilometers per second were still conspicuous, and had *not* moved in closer as the emission narrowed. 4686 was stronger than hydrogen beta. No observation was made of the visual region for the coronal lines.

A third three-night cloudy interval preceded observations on February 25th, when underexposed plates showed little change. The coronal line in the red, at 6374, was still about one fourth as strong as hydrogen alpha.

By March 3rd, the coronal lines seem to have dimmed down until they were lost in the continuous spectrum. In the red there is a continuous spectrum due to the unresolved *M*-type giant companion of the nova.

T Cor Bor seems to be unique among observed novae in having a very high temperature near maximum, capable of exciting He II. Like other novae, however, it showed increasing excitation as the light declined — enough to bring out the coronal emissions at 5303 and 6374. The most remarkable feature is the narrowing of the emission lines, although RS Ophiuchi has performed the same trick. Usually, the bands emerge shortly after maximum light with a width that lasts with relatively little change all the way down the decline of a nova's brightness. (Temporarily broader bands come in, but the *principal* bands don't change much in width.) This is taken to mean that the "shell" or mass of gas causing the absorption lines is continually expanding from a nova at a more-or-less uniform rate. T Cor Bor deviates as far as any star could from the usual relation connecting velocity of the absorption and the rate of decline.

The star's emission spectrum differs very little, in its general composition, from that observed at minimum light a couple of years before the outburst.

(*Continued on page* 17)

The blue region of the spectrum of the recurrent nova, T Coronae Borealis, photographed by Dr. McLaughlin on February 11th and 16th, with a titanium arc comparison spectrum.

Atoms, Stars and Cosmic Bombs

By Robert R. Coles, *Hayden Planetarium*

IN HIS announcement of the first use of the atomic bomb in combat President Truman said:

"It is the harnessing of the basic power of the universe. The force from which the sun draws its powers has been loosed against those who brought war to the Far East."

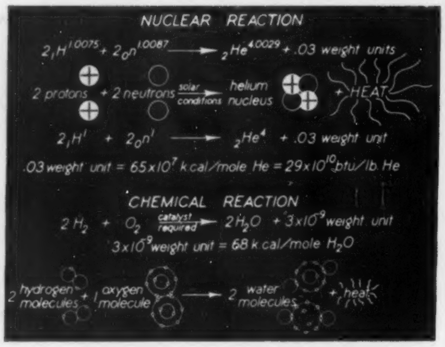
Whatever else may result from this event, it has already inspired tremendous popular interest in every branch of physical science, as reflected in the press, on the radio, and in increased planetarium attendance. And in so doing it has helped, more perhaps than anything else, to stress the value of research in pure science and to emphasize the important interrelation of physics, chemistry, and astronomy.

Through great telescopes, man explores the universe beyond the earth. This he views as a dynamic system, complexly organized and of such dimensions that a mere recitation of the figures involved staggers the imagination. At the other extreme is the realm of the atom — sub-microscopic — also of great complexity, and so minute that it is impossible for most of us to comprehend its littleness.

Once these two (the stellar universe and the atom) were considered far apart and almost unrelated. Today we know that they are closely bound together and that research in either field provides material useful in the other. The fact that atomic energy is the basic power in the universe is a truth that has become increasingly apparent through the years.

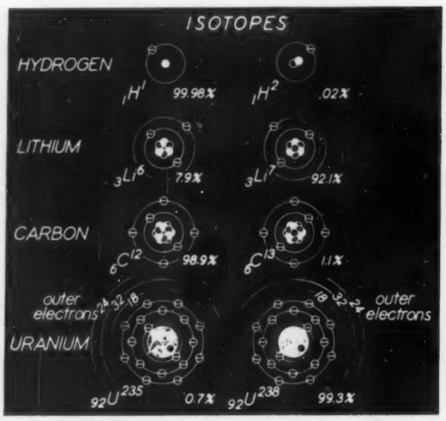
But what is this mysterious thing that we call "atomic energy"? Judging from some recently published popular accounts, one might believe that man had suddenly discovered something entirely new and out of this world.

In one sense, hundreds of everyday phenomena result in the release of atomic energy. Such commonplace happenings as the burning of coal, the combustion of gasoline vapor in an automobile engine, and the electrolysis of water, are familiar examples. In each of these energy is released. This energy results from changes in atomic structure. But here it is the outer parts or electrons of the atoms that are involved. Through a chemical reaction, the arrangement of these electrons is changed in the building up of various compounds or in the breaking down of other compounds into the elements of which they were composed. But the terrific effects that followed the atomic bombing of Hiroshima last August resulted from the splitting of the inner parts or nuclei of the atoms, with the release of almost unbelievable quantities of energy. This is more properly known as *subatomic energy*.



A nuclear reaction, whereby the sun gets its energy, and a chemical reaction, showing the formation of water, are here compared. Note the tremendously greater energy per mole released in the nuclear reaction.

As everyone knows, the atomic bomb did not spring into existence full-blown. It resulted from a vast two-billion-dollar government-sponsored project that was established under the pressure of war. But the amazing success of this project would have been impossible except for the groundwork of earlier research in atomic physics. The dawn of this science came during the last decade of the 19th century, with two events of far-reaching significance. The radioactive properties of uranium were discovered by H. Becquerel in 1896, and the far more radioactive radium was isolated by the Curies in 1898. These revolutionary achievements meant that the atom could no longer be considered as representing the ultimate in the structure of matter.



Isotopes of an element have the same number of ring electrons and therefore the same chemical properties. They differ in the number of neutrons in their nuclei and have different masses. The percentages of isotopes which make up ordinary samples of some elements as found in nature are shown in this diagram.

Almost immediately after the discovery of radium, many scientists in Europe and America began experimental work in atomic physics. Sir Ernest Rutherford found that radium gave off *alpha, beta,* and *gamma* rays; but the alpha rays were later shown to consist of particles identical with the nuclei of helium atoms (possessing two positive charges), the beta rays were actually fast-moving negative electrons, and the gamma rays were electromagnetic radiation (of the same nature as light) of extremely high frequency and great penetrating power. Evidently, the radium atoms spontaneously decomposed to form other elements and to release some of the fundamental particles which compose the nuclei of all atoms.

Radium is only one of some two-score radioactive nuclei in the three natural radioactive series; the final disintegration of each of these series produces the common element lead. It was not until 1919, when Rutherford bombarded nitrogen with alpha particles, that artificially radioactive elements were produced. The helium nuclei combined with the nitrogen to produce oxygen and hydrogen, and thereafter many more elements yielded to the bombardment of various particles produced by man-made electrostatic generators, by cyclotrons and other so-called *atom smashers*. In these operations, scientists succeeded in actually transmuting elements and learned at first hand of the stupendous quantities of energy that are locked in the heart of the atom.

But theory had been waiting for just such results. In 1905, Einstein suggested that the tremendous energy of radioactive decay might in part be accounted for by the conversion of some of the mass of an atom into energy. This required a restatement of the laws of the conservation of energy and matter, and the experiment of the atomic bomb has made very practical use of the fact that matter and energy are different forms of the same phenomenon.

In 1939, another epoch-making step was taken which led directly to the atomic bomb. Two German scientists succeeded in producing a complete split, or *fission,* of a uranium nucleus into two parts of the same order of mass. We had only succeeded in "chipping" the atom before this, with relatively small releases of energy. Uranium fission made possible the development of chain reactions among large masses of uranium atoms; also it led to the production of neptunium and plutonium, two new ele-

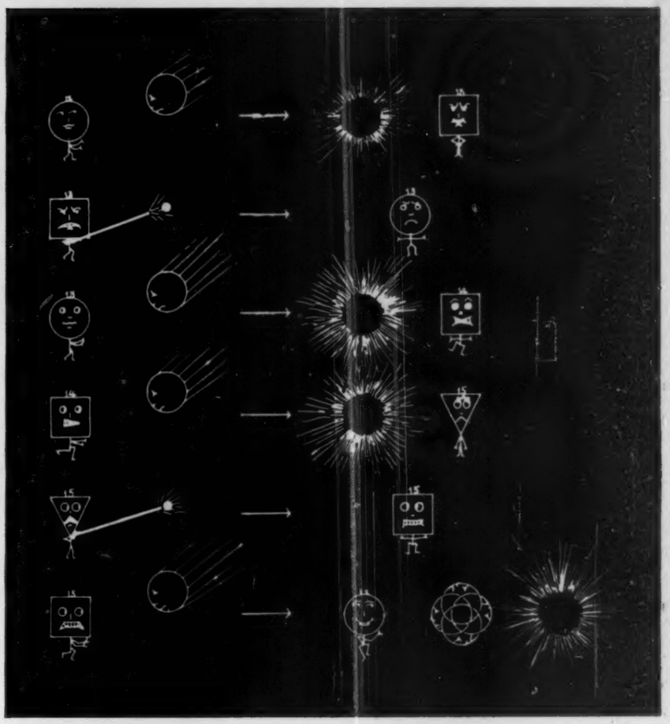
ments (93 and 94). Recently, elements 95 and 96 have also been produced.

Since the release of the atomic bomb story, such words as U-235, isotopes, deuterium, chain reaction, neptunium and plutonium, have found their places in everyday conversation. To the average citizen, without scientific background, they may seem rather vague in meaning, and the general picture of how they fit together may be confused, but of their importance in the scheme of things there can be no doubt. All this was settled with the explosion of the first atomic bomb.

The discovery of subatomic energy belongs within the past half century, but the stellar universe scintillates with visual evidence of atomic energy changes that have been going on for countless millions of years. For centuries man had speculated on the source of solar energy, lately realizing that if the explanation could be found for the sun it would probably apply to most other stars in the sky as well.

The ancient theory that the sun was on fire had to be discarded for the simple reason that the sun is too old; if its energy were generated by ordinary chemical combustion, it would have burned itself out long before now. Also, chemical compounds which are the products of combustion cannot exist at the tremendously high temperatures that prevail in the sun's interior. The famous Helmholtz contraction hypothesis, proposed in 1854, also had to be discarded in view of the sun's age. This proposal was that the sun maintained its temperature by continual gravitational contraction, but it gives out energy at such an enormous rate that it would have to contract too fast to live long that way.

Finally, research in nuclear physics suggested the theory that subatomic action taking place in the deep interior of the sun transmutes elements with a consequent change of matter into energy. The currently accepted mechanism is the *carbon cycle,* proposed by Dr. Hans Bethe, of Cornell University, in 1938. What occurs is a series of reactions which return to the point of starting after six steps. Carbon acts as a catalyst in changing four hydrogen nuclei into one helium nucleus. This nucleus weighs less than its originally separate components; the lost mass appears as the energy by which the sun shines.



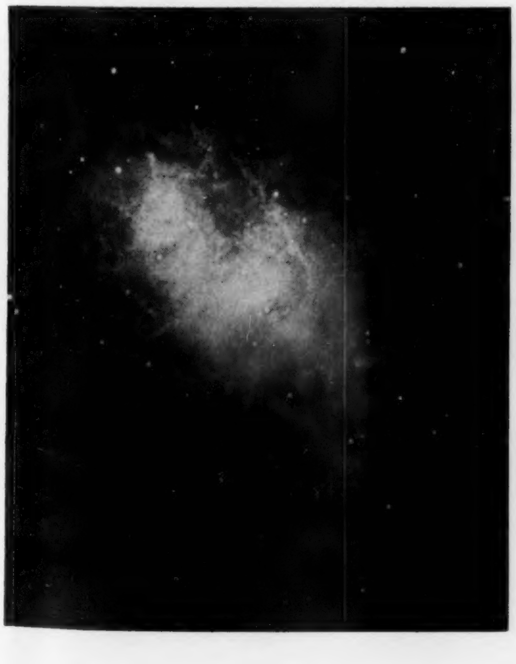
The carbon cycle of solar energy generation, as conceived by Dr. Cecilia Payne-Gaposchkin, of Harvard. Carbon of atomic weight 12 is the first actor on the scene (top line, left). Hydrogen nuclei (protons) are the fast-flying fellows in acts 1, 3, 4, and 6. In the same acts, gamma-ray bursts appear, while in acts 2 and 5 positrons are ejected. Carbon 13, nitrogen 13 and 14, oxygen 15 also take part, but in act 6, rejuvenated carbon returns to the scene, along with a helium nucleus in place of the four protons used in the cycle.

So far as the stars are concerned, this also seems to explain the energy production of those belonging to the main sequence on the Russell (spectrum-luminosity) diagram. Other explanations are needed, however, for other stellar types, but that nuclear reactions are involved there is little doubt.

Strong evidence pointing to nuclear fission processes in the stellar universe comes from the presence of cosmic rays. These mysterious radiations (particles or photons) have very great penetrating power, much greater, indeed, than either X-rays or gamma rays. They have been known to penetrate more than 15 feet of lead. They are stronger high in the atmosphere than near the surface of the earth, and the prevailing theory is that they may result from some tremendous energy-matter transformations in the cosmos — perhaps from the bursting of super-atomic bombs on the far horizons of space. Such explosions have been observed in the bursting of the supernovae. Perhaps the cosmic rays detected on earth at the present time were ejected during vast star explosions that took place millions of years ago. We learn that Professor E. O. Lawrence is supervising the construction of a great 4,000-ton cyclotron at the University of California in which he hopes to produce man-made cosmic rays. This work may help to solve the mystery of cosmic rays.

What is believed to be the debris of a supernova that burst forth in past ages may be seen through the telescope today as the famous Crab nebula in Taurus. Comparison of photographs at long intervals shows that it is actually expanding; some 900 years ago it was probably a point of light, comparable to a star. Supporting these calculations is the record of a Chinese astronomer who observed an exceptionally bright star in that same part of the sky in the year 1054. This coincides very nicely with the theory. So here we may be viewing the debris of a tremendous cosmic bomb that burst before the days of the Norman Conquest!

The Crab nebula may have resulted from the explosion of a "cosmic bomb."



NEWS NOTES

By Dorrit Hoffleit

OPERATION MUSK OX

A Canadian military winter exercise, believed to be of greater civilian than military value, is described by Dr. Peter M. Millman (Squadron Leader, R. C.-A. F.) in the *Journal* of the Royal Astronomical Society of Canada. Some 50 trained personnel, mainly from the Canadian Army Air Force but including a few U. S. experts, set out in February on a 3,000-mile trek starting at Churchill and ending at Edmonton. The most northerly latitude to be reached is over 70 degrees, at Victoria Island, Denmark Bay.

The purpose of the expedition is to study conditions in this little-explored Canadian north. Research problems under investigation fall under 24 separate headings, among them meteorology, the earth's magnetic field, radio and radar performance, methods of navigation, and aurorae. Dr. Millman emphasizes the work on aurorae, which are associated with magnetic disturbances. Regular observations are to be made from fixed ground stations as well as by the mobile party. If feasible, observations from aircraft are to be obtained. These data could be usefully supplemented by observations "at home," for which Dr. Millman has solicited the aid of members of the R.A.S.C.

ADRIAAN VAN MAANEN

Word has been received of the death in January of Adriaan van Maanen, of Mount Wilson Observatory. Most of the work on proper motions and trigonometric parallaxes done at that observatory was Dr. van Maanen's responsibility. An important white dwarf bears his name — a star within 13 light-years of the sun, and among the earliest of the white dwarf stars to be recognized as such.

Many of his undertakings were beset with serious observational difficulties. We cannot but admire the courageousness of his tackling positional or parallax measurements (which at best require extreme accuracy) of objects of abnormal color and hazy definition, such as the planetary nebulae, and nebulous condensations in the spiral arms of remote galaxies. His early work on internal proper motions in the arms of spirals introduced a colorful passage into the history of the theory of "island universes." V. M. Slipher, in 1917, had determined radial velocities of several condensations in spiral nebulae. Van Maanen set himself the task of determining the proper motions. A comparison of the two results should then have given an indication of the distances. The results, implying great proximity of the galaxies, appeared to be the death blow to the island-universe theory. Its resurrection came in 1924 with de Sitter's modification of Einstein's theory, which appeared to be supported by Slipher's spectroscopic observations provided the distances of the galaxies were large. Lundmark, of Sweden, then remeasured some of van Maanen's plates and obtained apparent motions only 1/10 as great. It was evident that the haziness of the measured objects did not permit the accuracy demanded for quantitative conclusions; as a pioneering attempt, however, the project was commendable.

Van Maanen's name appeared frequently for 30 years in the *Contributions* from Mount Wilson Observatory. The serious student of parallaxes will find among his papers not only many parallaxes of comparatively faint stars, but numerous valuable discussions of the astronomer's ever-present problem of the evaluation of systematic errors in the reduction of observational material.

VATICAN ASTRONOMY

One of the first publications to be received from Italy after the war is a paper by Father Stein commemorating 50 years of "Specola Vaticana" (1891-1941). The achievements of the Vatican astronomers during this period — work on the *Carte du Ciel,* Hagen's variable star atlas, investigations on spectral classifications — are indeed worthy of appreciation.

It is of interest to note that the famous Father Hagen went to the Vatican early in the century from Georgetown, D. C. Another American Jesuit, Rev. W. J. Miller, who received his Ph.D. at Harvard in 1943, has sailed to join the staff of the Papal Observatory, Specola Vaticana, at Castel Gandolfo. He is the only American on the staff.

ORNITHOLOGY FOR STAR-GAZERS

Early in the century (1902-1906), a few attempts were made to study the nocturnal migration of birds from observations of their apparent transits across the bright face of the moon. Astronomer Joel Stebbins in 1906 published a paper demonstrating a method for computing the heights of flying birds from such observations. It is essentially the same problem as determining meteor heights, but the necessary baseline between the two observers is only a few feet instead of several tens of miles.

William A. Rense, of Louisiana State University, calls attention to this neglected method and hopes to interest amateur astronomers. Data on heights, numbers of birds passing per hour, and directions of flight are desired. The low contrast between the appearance of birds and the general sky background makes the observation of migratory birds difficult, even in daytime, so that many pass unseen. Projected against the bright moon they are easily seen if they are nearby. Low-power telescopes, about 15x to 30x, are preferred for the observation; higher powers will give trouble because of the difference in focus between the moon and the birds, which are likely to be between 1,000 feet and a mile away. For details on observing and the computations, see *Popular Astronomy,* February, 1946.

JAPANESE WARTIME ASTRONOMY

We have just received six brochures of the Japanese *Journal of Astronomy and Geophysics* published by the National Research Council of Japan during the years 1941-44. Twenty-two weighty astrophysical and mathematical-astronomical papers are included, as well as abstracts of over 100 notes and papers appearing in other Japanese publications. The astrophysical problems of the planetary nebulae, the total eclipse of September, 1941, and solar system orbit problems are the most numerously represented topics.

ON THE OWNERSHIP OF METEORITES

Laws in regard to ownership of a meteorite found on another man's property are in no wise uniform. (See February, 1945, New Notes.) While we feel that the landowner is entitled to some claim, it would obviously be for the greater advancement of science if all recovered meteorites went to scientific institutions. Unlike precious stones, these missiles from heaven have no great practical or commercial value, except as souvenirs. To the meteoriticist, they hold a key to the age of the universe, the composition of interplanetary material, and tangible evidence of what might in rare instances hit the space ship of the future.

In discussing the question of ownership, in *Popular Astronomy,* Dr. Lincoln LaPaz, of the Society for Research on Meteorites, calls attention to one of the oldest laws, Roman Law XXX, which pertains to the division of treasure between the finder and the owner of the land whereupon the treasure was found. "Since the present rapid growth of interest in the recovery of meteorites will inevitably lead to controversies concerning ownership in all parts of the United States, steps should be taken for the establishment in those states where no ruling . . . has yet been made, of a ruling at least as just and as well-founded as the Roman Law XXX," Dr. LaPaz believes.

Amateur Astronomers

FOURTH NATIONAL CONVENTION AT DETROIT JULY 4TH WEEKEND

THE DETROIT Astronomical Society, along with other groups in the Detroit area, will be host to the Fourth National Convention of Amateur Astronomers, with principal program activities to be held on Friday and Saturday, July 5th and 6th, this year.

The headquarters and meeting place of the convention will be the Cranbrook Institute of Science and the Cranbrook School for Boys, located in Bloomfield Hills, a suburb to the northwest of Detroit. Convention delegates and their families will have no housing problems, for the Cranbrook School will provide rooms and three meals for $5.00 a day per person.

This fourth gathering of amateur astronomers on a national basis was to have been held in Detroit on July 4-5, 1942, by invitation of the Detroit Astronomical Society made at the Third National Convention in Washington, D. C., in July, 1941. At that time, provision for holding the Fourth National Convention in Detroit the following year was included in the proposed by-laws of the Amateur Astronomers League of America. Wartime difficulties made it impossible to hold a convention in 1942, and also prevented final organization of the League.

The prospect of a busy gathering held in the superb surroundings of the Cranbrook headquarters is enhanced by the attraction of the modern exhibits of the Cranbrook Institute of Science and by the many other scientific institutions in and around Detroit. Not the least of these are the University of Michigan Observatory at Ann Arbor and McMath-Hulbert at Lake Angelus.

A.A.F.I. Tenth Anniversary

For the past decade, the Amateur Astronomers of the Franklin Institute, in Philadelphia, has been a very active group in both telescope making and observing, and has fulfilled the place for it included several years earlier in the original plans for the Franklin Institute.

Among the present activities of the A.A.F.I. is *The Observer*, the society's monthly bulletin, now in its eighth volume. Pages 2 and 3 of the January issue contain an enticing announcement of the 10th anniversary dinner, which was held on February 4th.

The 20-inch pyrex blank presented to the club in July, 1939, by its first president, D. Robert Yarnell, is now being parabolized.

Dayton A.T.M.'s

At the present time, the Amateur Telescope Makers of Dayton, Ohio, have about 15 members, most of them having built their own telescopes and photographic equipment. As a club project, a 20-inch mirror is in the process of being polished, and is to furnish the nucleus of an observatory for use by various schools of the city as well as by members of the society.

F. E. Sutter, president of the Dayton amateurs, writes that meetings are held on the third Saturday of each month at various members' homes. These are usually dinner meetings where there is "a variety of good food and no one ever goes away hungry."

In addition to Mr. Sutter, who may be reached at R. R. 7, Dayton 9, the officers of the society are J. U. Brown, 27 Waverly Ave., Dayton, vice-president, and W. C. Braun, New Lebanon, secretary-treasurer.

THIS MONTH'S MEETINGS

Chicago: Following a discussion of the April evening sky and a question box period, the Burnham Astronomical Society will this month hear Professor Clarence R. Smith, of Aurora College, speak on "Knocking at the Doors of the Great Observatories." The meeting is on April 9th at 8 o'clock, Chicago Academy of Sciences Auditorium.

Cincinnati: Dr. L. H. Aller, of Kirkwood Observatory, will lecture on "Planetary Nebulae" at the April 12th meeting of the Cincinnati Astronomical Association, at the Cincinnati Observatory at 8 o'clock.

Cleveland: "The Age of the Universe" will be discussed by Dr. S. Chandrasekhar, of Yerkes Observatory, on April 5th at the meeting of the Cleveland Astronomical Society. The group meets at Warner and Swasey Observatory at 8:00 p.m.

Detroit: Meeting on April 14th at Wayne University, at 3:00 p.m., the Detroit Astronomical Society will hear Dr. Orren Mohler, of the McMath-Hulbert Observatory, who will show the latest films of the sun.

Geneva, Ill.: The Fox Valley Astronomical Society will hear an illustrated lecture by William Siekman, Jr., subject to be announced, at its meeting on April 16th. The group convenes at the Geneva City Hall at 8 o'clock.

Indianapolis: "Features of the Moon" will be discussed by Walter Wilkins before the Indiana Astronomical Society on April 7th, 2:15 p.m., at Odeon Hall.

A Million Observations

The American Association of Variable Star Observers, more familiarly known in the ranks of amateur and professional astronomers as the A.A.V.S.O., is on the last lap toward completing its first million individual observations of the brightness of variable stars. From data kept at the office of the society's recorder, Leon Campbell, at Harvard Observatory, it is evident that this goal should probably be attained late in April or early in May.

The achievement represents the efforts over 35 years of A.A.V.S.O. members, largely amateur astronomers, in spending countless hours observing the light fluctuations of some hundreds of variable stars. This is a necessary astronomical task which professional astronomers alone would never have had time to do.

May 3rd and 4th, dates for the spring meeting of the A.A.V.S.O. at Smith College Observatory, fall near the time when announcement of the millionth observation may be made. The meeting at Northampton will be held at the invitation of Dr. Marjorie Williams, who is 1st vice-president of the society. The program will start Friday evening, with sessions for papers Saturday morning and afternoon. A luncheon gathering is arranged for Saturday noontime, in lieu of an evening dinner.

Madison, Wis.: Professor W. W. Beeman, of the University of Wisconsin, will speak on the topic, "Physics as Applied to Astronomy," at the meeting of the Madison Astronomical Society, April 10th at 8:00 p.m., in Sterling Hall.

New York: At the meeting of the Amateur Astronomers Association on April 3rd, Dr. Clyde Fisher, honorary curator of the Hayden Planetarium, will lecture on "The Planetarium Instrument," at 8 o'clock in the Roosevelt Memorial building, American Museum of Natural History.

The Junior Astronomy Club will hear Miss Ida Barney, of Yale University Observatory, speak on "Star Catalogues, Old and New," on April 19th. The meeting is at the Roosevelt Memorial building, at 8:00 p.m.

Philadelphia: The Rittenhouse Astronomical Society will meet jointly with the Physics Club of Philadelphia on April 12th at 8 o'clock. Dr. George Gamow, of George Washington University, is to speak on the subject, "Origin of the Universe."

Pittsburgh: The annual quiz program will be the feature of the regular meeting on April 12th of the Amateur Astronomers Association, with Leo J. Scanlon as quizmaster. The meeting starts at 8:00 p.m., in the Buhl Planetarium.

AMERICAN ASTRO

Here are highlights of some papers prente... Astronomical Society. Complete abstra... w

Companion to Rasalhague Discovered

IN THE COURSE of redetermining Allegheny Observatory parallaxes of some of the brightest stars, Dr. Nicholas E. Wagman found a variable proper motion for the star Rasalhague (Alpha Ophiuchi) indicating the presence of a dark companion. Previous observations of bright stars for parallax measurements involved the use of a rotating sector with an extremely narrow opening to reduce the light of the bright star to equality with 10th-magnitude comparison stars. Currently, a neutral filter which absorbs seven magnitudes is used in conjunction with a sector of moderate opening to reduce the light of the bright star to magnitude 12.5. The latter method produces round instead of elongated images of the bright star and allows the use of fainter comparison stars. The increase in error caused by photographing through the filter is 15 per cent, the same as produced by the narrow sector.

It was in the course of these trigonometric distance measures that Rasalhague was found to be moving in an 8½-year orbit of semimajor axis 0.09 second of arc, presumably because of the gravitational action of the invisible companion. The current series of observations began in 1934. The earlier series extends from 1918 through 1921 and confirms the variable motion. Assuming the distance of Rasalhague to be 56 light-years and the mass of the bright star to be 2.8 times that of the sun, the dark companion is a star similar to the sun and at a distance of 600 million miles from its primary. The bright star itself was announced as a spectroscopic binary by Frost in 1907, but subsequent observations have not definitely established the duplicity. The spectrum is classified by Mount Wilson as *A*0n. The few lines are wide and poorly defined; one line, that of magnesium at 4481 angstroms, has been measured as a double line at Yerkes Observatory.

Star Colors and Brightnesses

IT IS well known that in the spectral types from *G* to *M* the dwarf stars are definitely bluer than the giants. A study of the relation between color and absolute magnitude has been made by Drs. Joel Stebbins and A. E. Whitford, of Washburn Observatory, University of Wisconsin, as an extension of similar work by Dr. John S. Hall, of Amherst College, some 10 years ago. The Wisconsin astronomers have used a photocell in combination with violet and infrared filters. In agreement with previous observers, they find that the difference in color between giants and dwarfs of the same spectral type begins between *F*5 and *G*0, reaches a maximum near *K*0, and is then much smaller in the *M* stars. Also, in this interval from *G* to *M* the colors of normal giants and subgiants are uniformly between those of the dwarfs and supergiants. Since the greater redness of the supergiants might also be caused by selective space absorption (they are distributed at great distances), only stars in high galactic latitude or at distances less than 100 parsecs were used.

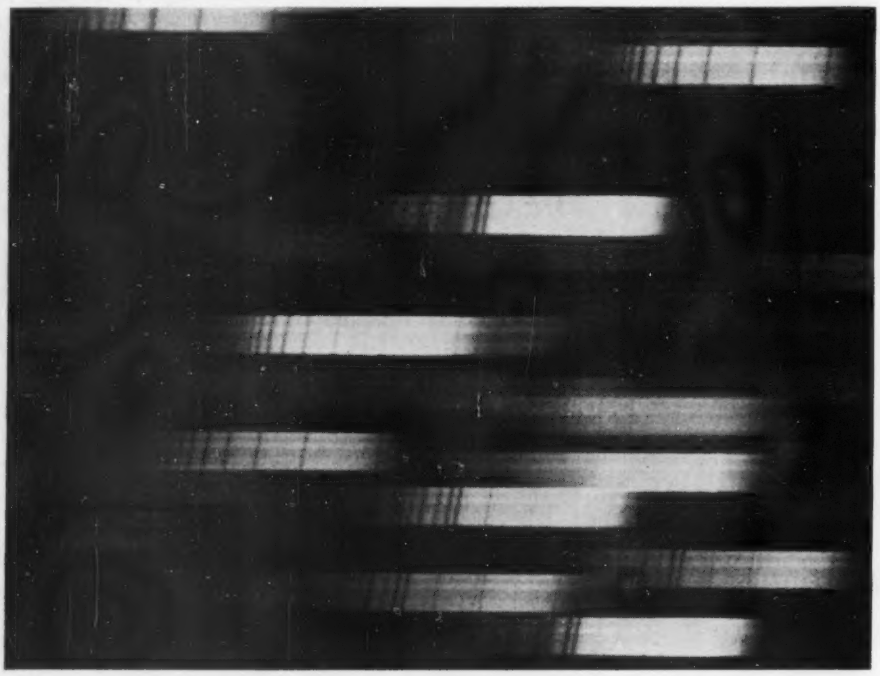
When the colors are plotted against absolute magnitude for a given spectral type, such as *K*0, the difference between intrinsically bright and faint giants is greater than the difference between faint giants and dwarfs. As color is a function of temperature, the corresponding relative temperatures are 3,600 to 4,700 degrees for the *K*0 giants, while the average dwarf of this class is at 5,300 degrees absolute.

In statistical studies of large numbers of stars, the relatively few supergiants and subgiants may have little effect upon the mean color of a spectral type, but for individual stars the color of a giant is a definite function of its absolute magnitude.

Case Schmidt Observations

FIRST contribution made through the use of the 4-degree, 24-inch objective prism attached to the Burrell Schmidt telescope of the Warner and Swasey Observatory was reported by Drs. J. J. Nassau and C. K. Seyfert, of the Case School of Applied Science. The investigation dealt primarily with the spectral-luminosity classifications of all the BD stars within five degrees of the north celestial pole. Spectral criteria were established to place the classification on the Henry Draper system; combining these determinations with the magnitudes and colors given in the Mount Wilson *Polar Catalogue* indicated that the selective absorption in this important part of the sky increases linearly to 0.30 magnitude at 450 parsecs and remains sensibly constant thereafter.

Dr. Nassau and Virginia Burger described work with the Schmidt camera employing a neutral-density filter to establish standard sequences of red magnitudes to a limiting value of magnitude 15 at the north celestial pole and in Mount Wilson selected areas 39, 40, 64, and 65. The neutral filter was made by the Eastman Kodak Company by depositing on one half of a circular piece of glass 7¾ inches in diameter a coating of white gold. The thickness of the glass was 0.5 millimeter, and another identical piece of glass was bound to



The spectra of many stars (some fainter than magnitude 12.5) can be photographed simultaneously by means of the 4-degree objective prism attached to the Warner and Swasey Schmidt camera. This is a portion of a plate exposed 45 minutes and here considerably enlarged. With a second 2-degree prism recently put into use with this same telescope, spectra of stars nearly as faint as magnitude 13.5 can be obtained. Both prisms were manufactured by Bausch and Lomb Optical Company (which supplied this engraving), and optically finished by the Warner and Swasey Company.

...RONOMERS REPORT

...s presented at the 74th meeting of the American ...bstracts will appear in the Astronomical Journal.

the filter in order to protect its surface. Spectrophotometer tests showed it to be neutral for all practical purposes for wave lengths above 3660 angstroms; a year later, the filter was found still to reduce all wave lengths non-selectively. Eastman type 103-E and later 103a-E plates were combined with a No. 22 Wratten filter to give an effective wave length of about 6200 angstroms.

Sporadic Meteors

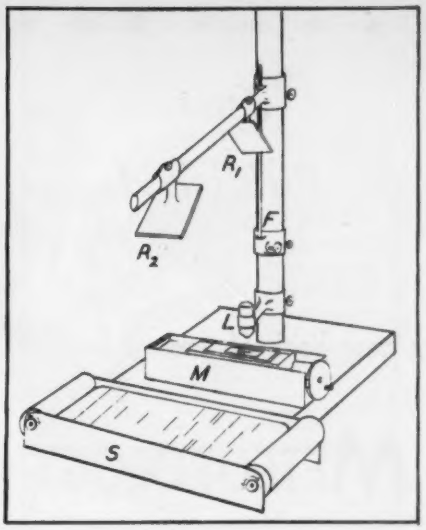
AMONG 28 meteor orbits so far determined from photographs taken simultaneously at Harvard's Cambridge and Oak Ridge stations, Dr. Fred L. Whipple finds 12 to be those of sporadic meteors. Of these, five are similar to Jupiter-family comet orbits; one is of the Saturn-family type; five are long-period, with random inclinations; and one is of uncertain period. No meteor with a reliably determined hyperbolic motion has been observed, so there is no evidence that any of these sporadic meteors came from outside the solar system.

A Projection Method for Measuring Spectra

FROM VICTORIA, British Columbia, where the Dominion Astrophysical Observatory is located, Dr. R. M. Petrie sent a paper describing the construction and operation of a machine designed to shorten the time required to measure and reduce a stellar spectrogram for determining the radial velocity of a star. Radial velocity measures often form a major part of the labor involved in some astronomical research problems; statistical investigations require the measurement of hundreds of plates. At Victoria, an advance was made some years ago when projection methods were introduced to supplant the viewing microscope and reading lens. This did not cut down the number of mechanical processes involved in measurement, but it did increase the ease and rapidity of work by reducing appreciably the fatigue experienced by the operator.

In the new machine, the spectrum is projected under high magnification (about 70 diameters) upon a viewing screen on which are ruled the positions of the comparison lines and the zero-velocity positions of the stellar lines. By mechanical and optical means, it is then possible to eliminate the measurement of the comparison lines and almost all of the process of reduction.

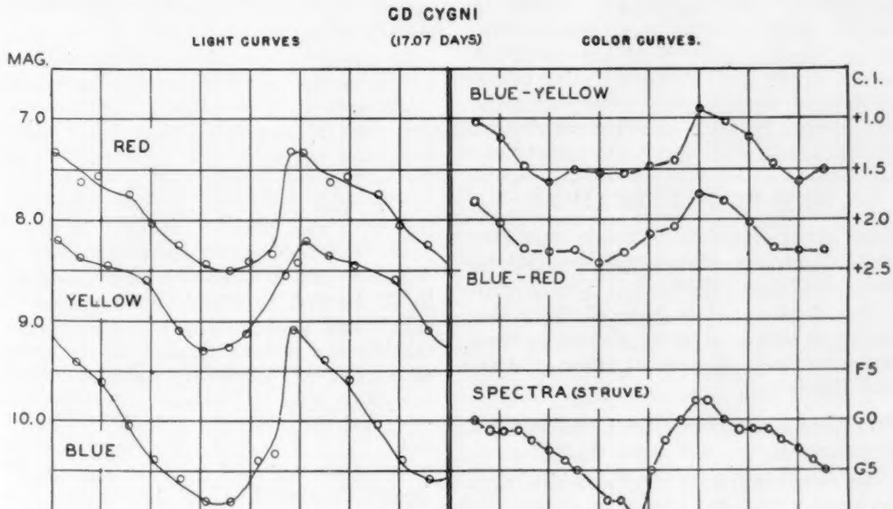
The time required to measure and reduce a spectrogram is cut to about one half that needed with the ordinary measuring micrometer, in return for which the average probable error of a single plate, from internal agreement, is about 10 per cent greater in measures with the new machine.



The projection comparator used at Victoria for measuring spectra. M is the stage of a standard micrometer, and carries the spectrum plate. This is illuminated from below, and a greatly enlarged image of the spectrum, formed by the projection lens, L, and the plane mirrors, R_1 and R_2, appears upon the viewing screen at S. Overall magnification employed varies from 40 to 80 diameters; the slow-motion control at F provides for precise matching of the projected spectrum to the ruled scale of comparison line positions at S. A separate optical system (not shown) projects an enlarged image of index and reading to a convenient place near the operator.

Cepheid Colors in Cygnus

LIGHT CURVES of seven Cepheid stars in Cygnus have been determined by Father F. J. Heyden, S. J., of Georgetown University, as a result of work begun at Harvard Observatory. Three light curves were obtained for each star, from photographic plates sensitive to blue, yellow, and red light, respectively; the plates were exposed in two different telescopes at Harvard's Oak Ridge station so that each yellow or red plate was taken simultaneously with a blue one of the same region.



Light and color curves of the Cepheid variable star CD Cygni. The red, yellow, and blue light curves are at the left; the corresponding color indices (C.I.) in the upper right. In the lower right, the change in spectrum with period is shown. Note that the spectrum varies more than a whole spectral class.

Accurate color curves showing the variation of the blue-yellow and blue-red color indices have been derived from the three light curves of each of the seven stars. These color curves show a definite correlation with curves provided by Dr. Otto Struve, of Yerkes Observatory, showing how the spectral class of each Cepheid changed during its period of light variation.

The spectra of these Cepheids are nearly normal at minimum light, in each case, so Father Heyden used the observed color at minimum as a measure of the absorption of light by material between us and each star; this absorption produces a reddening or *color excess* which may be determined once the normal color index for the unobscured star has been established.

Five of the stars are located in the star-poor areas near the North America nebula, and these are found to suffer extinction from three to 4½ magnitudes photographic even though their distances range from only 400 to 900 parsecs. Evi-

(*Continued on page* 20)

BOOKS AND THE SKY

SCIENCE OF THE SEVEN SEAS

Henry Stommel. Cornell Maritime Press, New York, 1945. 208 pages. $2.50.

WRITTEN in an engaging style with many scientific sidelights, this small, well-illustrated book summarizes the physical and biological phenomena encountered on the seas and along their shores. In a pocket-sized book the multitude of subjects cannot be treated extensively, but the author has discussed briefly the principal observable phenomena in a wide range of sciences.

The first of three major sections covers the physical characteristics of the seas — the origin and peculiarities of ocean waves, submarine topography, tides, ice and icebergs, currents, and shore structure. Among the interesting topics discussed are the effects of submarine earthquakes, the nature and origin of the ocean-bottom ooze, Plimsoll marks on ships, the origin and prediction of tides, and the cause of great ocean currents like the Gulf Stream.

Atmospheric illusions — mirages, rainbows, and halos — introduce the section dealing with phenomena of the sky. A description of the upper atmosphere is followed by chapters on cloud forms and their significance, on lightning and electrical phenomena like St. Elmo's fire, and on the winds. A relatively long chapter reviews astronomy for the entertainment of those standing quiet night watches at sea.

The third section on ocean life consists essentially of photographs showing typical marine life. This reviewer hoped for a section on crustaceans and the biology of lagoon life which so many in the military services have recently observed at first hand to while away idle hours.

No book could cover such a range of topics without a few inaccuracies, yet it is unfortunate that the existence of mother-of-pearl and noctilucent clouds at heights up to 50 miles is passed over with the statement that "there are no clouds in the upper air." Wegener's hypothesis of drifting continents, the possible origin of ice ages through severe perturbations of the earth's orbit, and the two-star close-approach hypothesis for the origin of the solar system are presented with little indication that these suggestions are under heavy scientific criticism.

Science of the Seven Seas is an interesting and informative book. Anyone living on or near the sea, as well as the curious landlubber, will find it enjoyable and enlightening.

FLETCHER G. WATSON

FOTOGRAFIA ASTRONOMICA

Jose Galli. Correo Fotografico Sudamericano, Buenos Aires, 1945. 252 pages. No price given.

THIS book is written in Spanish as a general and practical introduction to the field of photography in astronomy, for amateurs. It is well written and illustrated, and has references to original papers and books which are very useful for the reader who would like to go deeper into this important subject. The material is presented in a simple and interesting manner, and the author, an enthusiastic Argentinian amateur astronomer, relates some of his experiences in the field and gives good advice for the beginner.

The contents cover general discussions of lenses and mirrors, co-ordinates, apparent movements of the stars; the photographic telescope, plates and filters, the laboratory, and the photographic process. A number of chapters are devoted to various kinds of astrographic cameras and their use. Special problems involved in photographing various types of astronomical objects, the sun, the moon, comets, the Milky Way, and so on, are treated. At the end of the book there is a catalogue of notable astronomical objects. Many of the photographs were taken with the 60-inch reflector of Cordoba Observatory; there are new diagrams which should interest the North American amateur.

In general the book is accurate. There are some points which could have been dealt with in more detail, for instance, that each photographic plate has a characteristic curve for each color, that is, for each wave length, and a comparison of this with the Purkinje effect. In dealing with the Schmidt camera, it would have been very useful to the amateur to mention and describe the new invention by Maksutov, in Russia, of a system in which are used only spherical surfaces, making the camera simpler for amateurs to construct. There are some few inaccuracies. The author states that because the focal surface in the Schmidt is curved, only films are used. Actually, plates have been employed very successfully, although they need special devices for curving them. He mentions that 70 per cent of meteors come from interstellar space; this is not so according to the latest results.

Many Spanish-speaking students of astronomy should enjoy this book, of which there is no close counterpart in English.

FELIX CERNUSCHI
Harvard Observatory

NEW BOOKS RECEIVED

ELEMENTARY ASTRONOMY, *Ernest Agar Beet*, 1945, *Cambridge University Press* (Macmillan). 110 pages. $2.00.

This English text is designed for a short course in school, or as an elementary home-study textbook. It contains many diagrams and illustrations.

ELECTRONS IN ACTION, *James Stokley*, 1946, *Whittlesey House*. 320 pages. $3.00.

An author well known in the field of popular science writing discusses the electron and its wide application in a growing number of industrial and scientific devices.

ASTRONOMY, What Everyone Should Know, *John Stuart Allen*, 1945, *Bobbs-Merrill*. 199 pages. $2.50.

An easy-to-read book which is designed to give the general reader or the beginner in astronomy an overall picture of the field.

ASTRONOMICAL ANECDOTES

VARIABLE INTERVALS, PERTURBATIONS, AND THE "LUNATIC FRINGE"

A LETTER from Fulton Jack, who practices law in Beatrice, Neb., raises an interesting point. He uses the estimable *Old Farmers Almanac* to extract some dates of perihelion and aphelion for the earth, with results that may surprise many of us. Here's the sort of thing:

	Perihelion	*Aphelion*
1943	Jan. 2^d 05^h	July 4^d 10^h
1944	Jan. 4 18	July 3 06
1945	Jan. 1 23	July 5 10
1946	Jan. 2 18	July 3 11
1947	Jan. 4 02	July 5 10

These values have been taken from the *American Ephemeris and Nautical Almanac,* and show readily what worries Mr. Jack. The intervals from perihelion to aphelion range from 180 days 12 hours to 184 days 11 hours; the intervals between perihelia range from 363 days 5 hours to 367 days 13 hours; from one aphelion to another may be as short as 363 days 1 hour or as long as 367 days 4 hours.

An explanation is desired by the observant Mr. Jack. While I am not a celestial mechanician, I believe I am safe in saying that the values in the table above have been derived by taking into account all the perturbations due to Venus, Mars, Jupiter, Saturn, and the moon. All these bodies can have an appreciable effect on the earth's perihelion distance and the time of its occurrence.

In discussing the transit of Mercury of November 2, 1697, the great Leverrier in 1858 evaluated the effects of other planets in altering the average or unperturbed distance of the earth from the sun. The moon's effect was to diminish it by 1,366 miles; that of Venus to diminish it by 1,291 miles; Jupiter lessened it by 2,378 miles; and Mars also diminished it by 297 miles. Mercury increased it by 28 miles, and Saturn by 37 miles. These all apply only to the instant of the transit, but they give a general idea of what can happen to a mean value of the earth's distance from the sun at any particular moment, calculated without regard to perturbations.

Mr. Jack and others who like such things might amuse themselves by finding years in which two perihelion passages of the earth took place. Naturally, this will mean that in some years no perihelion passage occurred! 1913 and 1921 are years that saw no perihelion; look the others up for yourselves.

What worries Mr. Jack in this matter of perihelia and aphelia is equally true of anything concerning the earth's motion. For example, intervals from vernal equinox of one year to the same of next year are by no means exactly equal; true, the range for a current five-year period is only 15 minutes, but there is a variation. The same thing is true, in approximately the same degree, if the intervals between successive equinoxes or solstices of any kind are taken.

And how about the lunations? Choose any year, and see if you can find any interval from new moon to new, or full moon to full, that is equal to 29 days 12 hours 44 minutes 2.8 seconds, the stated value of the synodical month. Trying it out on the year 1947, I find that the interval from a full moon to the next ranges from 29 days 11 hours 3 minutes to 29 days 15 hours and 12 minutes.

For even more fun, work on the lengths of the quarters of the lunations. Suppose we consider the intervals from new moon to first quarter. In 1947, they run all the way from 6 days 14 hours 51 minutes to 8 days 4 hours 50 minutes. If you ever have to make up a list of the phases of the moon for a calendar maker, rounding them off to the nearest day, you will know that it is a little while before he will accept your figures, because he notices that sometimes one quarter of a lunation follows another by only six days, while at other times the interval is eight days.

And this is the very sort of thing the "lunatic fringe" of astronomy seizes upon, to show that the astronomers don't know what they are talking about, and to use as a springboard to take off into their own weird theories, often sadly tangled with religion — the Christian religion, usually, and of course the King James version of the English translation. A local correspondent is unifying the calendar and the monetary system of the world, playing upon such silly things as that in each of the words Julius and Caesar there are *6* letters, and the Julian calendar was promulgated in *46* B.C. Thus we get 666, the number of the beast (*Revelations* 13:18). Have you lost a weekend, lately?

R.K.M.

OBSERVER'S PAGE

Greenwich civil time is used unless otherwise noted.

T Coronae Borealis and Other Phenomena

CURRENT events continue to interest observers this month, although T Cor Bor has now faded completely below naked-eye visibility and the mammoth sunspot group of early February has passed into history. Comet Timmers is still visible in moderate telescopes, and April brings its usual Lyrid meteor shower.

Announcement Card 1028 from the European clearinghouse at Copenhagen shows that a Dutch astronomer also discovered the current outburst of T Coronae Borealis. The card quotes a telegram from Oort, in Holland, reading, "Nova 1866 in Corona, new eruption, 3rd magnitude, discoverer Meesters."

T Cor Bor has had a precipitous decline, but no more rapid than that from its previous maximum in 1866, as the accompanying diagram shows. The current maximum has been displaced in relation to the maximum observed in 1866 in order that the curves would not overlap. Although the star was fully a magnitude brighter in 1866, its rate of decline has been nearly as great as it was then.

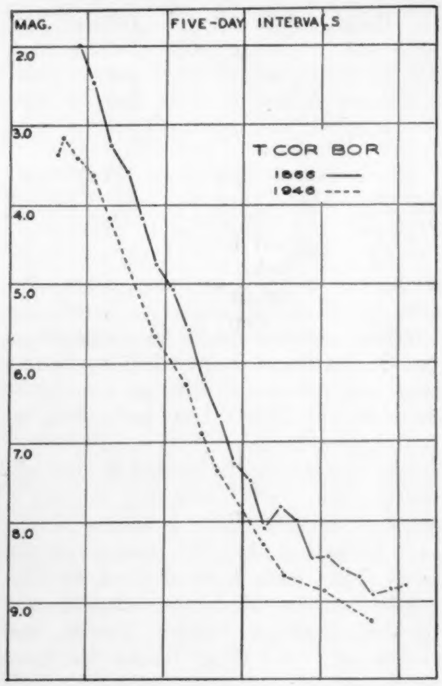
Data for plotting the curves was supplied by the American Association of Variable Star Observers. The points represent one-day means.

On the opposite page a pair of Harvard patrol plates gives the "before and after" history of the Northern Crown, with the nova indicated by the arrow. On page 7 are spectra of T Cor Bor, kindly furnished, with commentary, by Dr. Dean B. McLaughlin, of the University of Michigan Observatory.

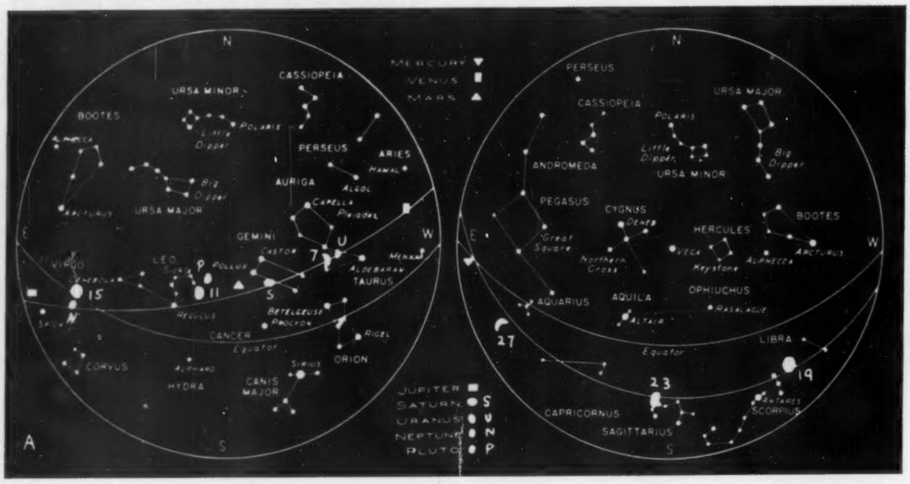
A number of observers have reported the return of the large February sunspot group. It survived its passage around the far side of the sun, but was considerably smaller on reappearance. Interference with radio communications was reported during early March, presumably associated with this solar disturbance.

Comet Timmers is now of the 9th magnitude, and its positions are predicted as follows: March 17, 7^h 19^m, $+74°.6$; April 2, 6^h 22^m, $+77°.9$; April 18, 6^h 01^m, $+80°.3$; May 4, 6^h 28^m, $+83°.0$; May 20, 8^h 41^m, $+85°.5$. By the end of May, the comet will probably be of magnitude about 9.5, but its fuzziness may make it appear considerably fainter than this estimate of its integrated brightness.

Spring stargazers can avail themselves



THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 5:30 a.m. local time on the 7th of the month, and at 4:30 a.m. on the 23rd. At the left is the sky for 7:30 p.m. on the 7th and 6:30 p.m. on the 23rd. The moon is shown for certain dates by symbols which give roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury, although at greatest western elongation on April 23rd, is a poor object for observing. It rises about 50 minutes before the sun during the latter half of the month.

Venus continues to emerge from the sun and is becoming a prominent object in the evening sky. During April it moves from Pisces into Aries, and by the 30th is between the Pleiades and Hyades in Taurus. At that time it sets nearly two hours after the sun. The planet's magnitude is —3.3, and in a telescope it appears nearly at the full phase, but only 11 seconds of arc in diameter.

Mars remains an evening object, moving eastward from Gemini into Cancer. It continues to lose its brightness as the sun gains on it. On the 19th, the Martian magnitude is +1.0. Then the planet is at quadrature, or 90° east of the sun; it sets at 1:30 local time. On the 9th, the moon occults Mars, but the event is not visible from most of the United States. However, watch the moon approach Mars on the night of April 8-9, and it will be very close when the pair sets at about 2 a.m. local time.

Jupiter dominates the midnight sky with its brilliance. It remains a few degrees north of Spica in Virgo, and shines as a star of magnitude —2.0.

Saturn can be seen during the first half of the night in Gemini. Its magnitude has decreased to +0.3, the same as the star Rigel.

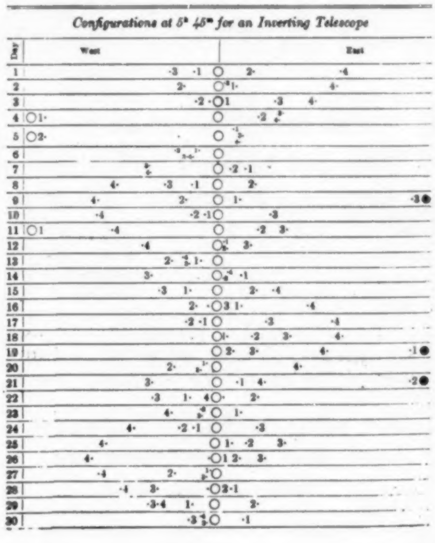
Uranus is too close to the sun for favorable observation until next August.

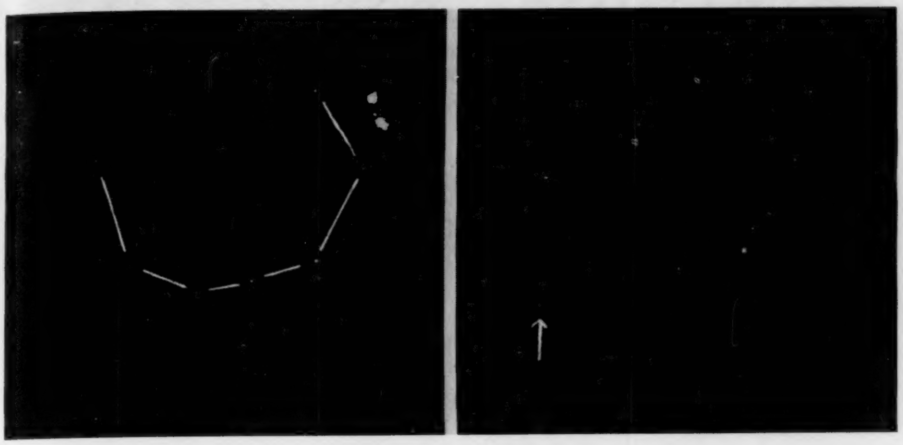
Neptune remains well placed for observation in a small telescope. It can be viewed most of the night in western Virgo. The position on the 15th is 12^h 27^m and —1° 18′ (1946), and the magnitude is +7.7.

EDWARD ORAVEC

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the **American Ephemeris and Nautical Almanac.**





A Harvard patrol plate of the Northern Crown (left) shows no trace of the nova. On February 9th this year, the star was very conspicuous, as shown in the picture at the right. Exposure times were nearly an hour.

of the annual shower of meteors radiating from the constellation Lyra and known as the Lyrids. Maximum of the shower should occur from the 20th to the 22nd, but its total duration will be from April 18th to 26th. Swift streaks are typical, but the Lyrids are not as numerous as other shower meteors — perhaps eight an hour can be seen after midnight. A gibbous moon will be in Scorpius and Sagittarius at the time of maximum.

MINIMA OF ALGOL

April 2, 6:24; 5, 3:13; 8, 0:03; 10, 20:52; 13, 17:41; 16, 14:30; 19, 11:19; 22, 8:08; 25, 4:57; 28, 1:46; 30, 22:36.

PHASES OF THE MOON

New moon	April 2, 4:37
First quarter	April 8, 20:04
Full moon	April 16, 10:47
Last quarter	April 24, 15:18

OCCULTATION PREDICTIONS FOR APRIL

Two bright stars, Beta Scorpii and Lambda Sagittarii, are to be occulted this month. Before sunrise on April 19th, the moon will hide Beta, 3rd-magnitude star in the head of the Scorpion, for observers in the Plains states and on the West Coast. Interpolate your position among those listed in the occultations predictions data to find the approximate time for your station.

Three days later, the eastern portion of the United States and Canada will be favored with an occultation of Lambda Sagittarii, a star of the same brightness as Beta Scorpii. At Washington, D. C., obscuration is from 1:28 a.m. to 2:25 a.m. EST, nearly an hour. Some United States' observers can predict this occultation closely by using the **a** and **b** quantities for station D, at Toronto.

8-9 **82 Geminorum** 6.2, 7:45.3 +23-16.6, 7, +89° +13° Im: **F** 6:57.7 +0.2 —1.5 119°; **G** 6:22.6 —0.6 —1.5 93°; **H** 6:47.1 —0.2 —2.3 135°; **I** 6:18.9 —0.7 —1.7 106°.

9-10 **Gamma Cancri** 4.7, 8:40.2 +21-39.8, 8, +63° —7° Im: **E** 5:26.6 —2.3 +0.9 46°; **F** 5:19.2 —1.3 —1.0 93°; **G** 4:43.4 —2.2 +1.2 52°; **H** 4:35.8 —1.9 —1.3 110°; **I** 4:23.8 —2.0 +0.6 70°.

11-12 **42 Leonis** 6.1, 10:18.9 +15-14.9, 10, +59° —18° Im: **A** 23:58.5 —1.8 +0.5 98°; **C** 23:49.9 —1.6 0.0 113°; **E** 23:30.6 —1.1 +0.4 113°; **F** 23:28.5 —1.2 —1.9 152°.

18-19 **Beta Scorpii** 2.9, 16:02.3 —19-39.6, 17, +71° +4° Im: **F** 13:10.1 —1.0 —1.5 103°; **H** 12:31.3 —2.0 —0.8 84°; **I** 12:16.8 —1.8 —0.5 63°. Em: **F** 14:19.4 —0.3 —1.2 276°; **H** 13:49.8 —1.4 —2.1 307°.

21-22 **Lambda Sagittarii** 2.9, 18:24.6 —25-27.2, 20, +65° +20° Im: **A** 6:29.6 —0.8 +0.1 131°; **C** 6:27.7 —0.3 —0.7 147°; **E** 6:33.8 . . . . . . 179°. Em: **A** 7:41.5 —2.2 +1.2 250°; **B** 7:43.0 —1.9 +1.1 254°; **C** 7:25.3 —2.5 +2.1 236°; **D** 7:28.8 —2.0 +1.7 244°; **E** 6:49.4 . . . . . . 204°.

21-22 **CD —25° 13170** 6.2, 18:26.0 —25-17.6, 20, +65° +6° Em: **A** 8:36.1 —1.9 —0.2 297°; **B** 8:33.9 —1.8 —0.1 301°; **C** 8:27.4 —2.0 +0.1 288°; **D** 8:23.7 —1.7 +0.2 294°; **E** 8:03.0 —1.6 +0.9 277°; **F** 7:36.7 —2.1 +2.2 241°.

For selected occultations (visible at three or more stations in the U. S. and Canada under fairly favorable conditions), these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, limiting parallels of latitude, immersion or emersion; standard station designation, GCT, **a** and **b** quantities in minutes, position angle; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5	**E** +91°.0, +40°.0
B +73°.6, +45°.6	**F** +98°.0, +30°.0
C +77°.1, +38°.9	**G** +114°.0, +50°.9
D +79°.4, +43°.7	**H** +120°.0, +36°.0

I +123°.1 +49°.5

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard time.

For additional occultations consult the **American Ephemeris and Nautical Almanac** and the **British Nautical Almanac**, from which these predictions are taken. Texas predictions were computed by E. W. Woolard and Paul Herget.

GREENWICH CIVIL TIME (GCT)

TIMES used on the Observer's Page are Greenwich civil or universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the GCT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

THE SPECTRUM OF T COR BOR

(*Continued from page* 7)

The narrowing of the bands must indicate a slowing down of the rate of ejection of gas. *There was no main ejected shell as in normal novae,* just a continuous ejection at decreasing speed as time went on. However, enough stuff was ejected to give a "shell" absorption spectrum, but no conspicuous shell emission bands.

DEAN B. McLAUGHLIN
University of Michigan Observatory

March 3, 1946.

THE C.D.A.L. COMPLETES ITS ACTIVITIES

(*Continued from page* 2)

A review by Dr. G. Neujmin, of the Poulkovo Observatory, recounts its wartime story and reports on plans for reconstruction and reorganization of astronomy in Russia.

Dr. F. A. Paneth, of the University of Durham, the leading authority on the ages of meteorites, contributes an account of this topic. From the uranium, thorium, and helium content of iron meteorites, radioactive ages are derived ranging for the different elements and various specimens from 60 million to 7,600 million years. The conclusion reached is that this evidence indicates the age of the solar system cannot be less than 7,000 million years. This is a **lower** limit; other lines of attack (dealing with the stellar system and nuclear-atomic processes for energy emission) yield ages not greater than 10^{10} years, the most favored figures being between 2 and 3 $\times$ 10^9 years — 2,000 million and 3,000 million years.

A colossal and valuable accomplishment, reported upon by Dr. Charlotte E. Moore, of Princeton (now with the Bureau of Standards), is the Revised Multiplet Table for spectral lines of astrophysical interest. Wave lengths and identification of over 23,200 lines likely to be found in stellar spectra are listed; in addition, predicted wave lengths for so-called forbidden lines (such as occur in tenuous emission nebulae and in the solor corona) are recorded for 2,550 lines.

Indeed, the farewell issue of the Newsletter brings concrete evidence of interest, happy prospects, and present progress in astronomical research. The Committee for the Distribution of Astronomical Literature deserves credit for its share in keeping the spirit alive.

DORRIT HOFFLEIT

GLEANINGS FOR A. T. M.s

How to Cement Lenses

THE AMATEUR who makes an achromatic lens will in all probability make one which is to be cemented, since in this form the lens is easier to handle and easier to mount. Also, cemented lenses which the amateur has in his possession (objectives, eyepiece lenses, and the like) may suffer breakdown of the cement over a period of time. This is especially true of astronomical instruments which are subjected to low temperatures, as when telescopes are used in the winter. Furthermore, in a broken-contact lens, about eight per cent of the incident light is lost in surface reflections, although commercially available coatings can reduce this to about one per cent or less.

It is therefore helpful for the A.T.M. to know something about the cementing of lenses, since it is a simple procedure, which he can easily accomplish himself.

The almost universally used cementing material is Canada balsam, sometimes called Canada turpentine. It is procurable from any chemical or optical supply house in either of two forms, liquid or stick; most people prefer the stick form.

The military services, for the past few years, used various types of thermosetting cements, made mostly of methacrylate derivatives, due to the breakdown of Canada balsam when subjected to extremes of temperature and to rough handling. However, beware of advertising which states that thermosetting cements are immensely superior to Canada balsam. Unless an instrument is to be treated with the hard knocks military instruments receive, or is to be subjected to severe temperatures, Canada balsam is completely satisfactory. It is less expensive, easier to apply, and when lenses cemented with thermosetting cement break down (as they do, upon occasion), heroic measures are necessary to get them apart for recementing.

Decementing Lenses Cemented with Canada Balsam

Breakdowns in lenses cemented with Canada balsam usually appear as starlike spots in the cement, due to crystallization of the balsam. These will spread in time, and cause loss in light transmission as well as possible undesirable diffraction effects.

To decement such lenses, it is necessary only to heat them to about 200° or 250° F., at which temperature the balsam becomes soft, and the lenses may be pushed apart. An electric hot plate is about the best device for this heating, although if this is not available, any suitable equipment may be used, including the oven of a kitchen stove. In the case of small lenses (3-inch and under), a cork stopper provides a good friction tool for sliding the lenses apart, as they are a little too hot to handle with the fingers.

The precautions to observe for prevention of breakage are not to heat or cool the lens too rapidly, and to prevent cold air drafts from blowing upon a hot lens. Otherwise, the heat will do the lens no harm.

After the lenses have been pushed apart, cover them with a dish, cloth, or anything available, to keep off cold drafts, and allow them to cool. When cool, the balsam should be thoroughly cleaned off. It is soluble in most organic solvents, alcohol being about the best.

Cleaning and Cementing

The equipment necessary for cementing with Canada balsam is some sort of clean hot plate, cleaning materials, cork stoppers, and, for each lens, two V-blocks. These are used to center the

lens, and may be of either metal or wood (see Fig. 1). A rubber air bulb and a camel's-hair brush about one inch wide complete the list.

The first requirement is to get the surfaces to be cemented absolutely clean. After the old cement is taken off with a solvent, clean the lenses with a good washing in soapy water, followed by rinsing in clear water, then wipe dry with a soft, clean cloth. If a detergent such as Orvus, Aerosol, or Dreft, is used instead of ordinary soap for this washing, it will dry without leaving a film.

If soap is used, the water rinse should be followed with a washing in alcohol,

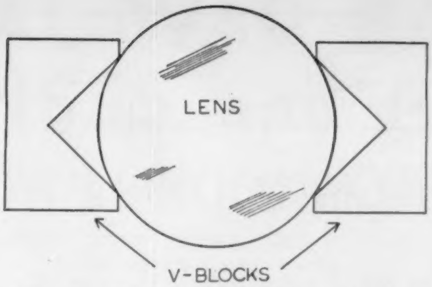


Fig. 1. V-blocks used for centering lens components.

acetone, or other organic solvent of the quick-drying variety. It is a little difficult to clean with these solvents without leaving streaks behind; best results will be obtained if the solvent is applied with a clean cloth, and then rubbed briskly with a dry cloth before it evaporates.

A piece of rayon will be found useful for a final wiping, as it is completely lint free and will leave no dust. Cementing should be done in as dust-free an atmosphere as possible.

Place the clean lenses on the hot plate (which also must be spotless), with the flint cemented side up and the crown upon it. This will prevent any dust from collecting on the surfaces to be cemented. Lifting tongs will be found useful for handling the lenses on the hot plate.

The lenses are heated to about 200° to 250° before the cement is applied. If no thermometer is available for measuring this temperature, heat them until they feel very hot to the touch, but not quite hot enough to burn. It should be possible to hold the fingers against them for two or three seconds. While heating, the lens should be turned upside down from time to time, keeping the crown and flint together, to assure that both components are heated to the same temperature. When ready, remove the crown from the flint and place it, cemented side down, on the hot plate.

Brush the flint with the camel's-hair brush, and cover it with cement. If liquid cement is used, place a small quantity in the center of the flint, and cook it until a bit picked up on the point of a knife will harden and flake off. If stick balsam is used, merely apply the stick to the hot lens and the balsam will melt off. Be sure the stick is clean and free of dust by wiping with a cloth dipped in alcohol. In the case of either type of cement, be sure all portions of the flint are covered with cement.

Now, brush the cemented surface of the crown, and place it upon the flint. Do not put it directly over the center, but slide it into place. Using a cork stopper, with considerable pressure, work out all bubbles, stroking them out to the edges as you would a charge of fine emery.

This is the most difficult part of the job. The hotter the lens, the easier the bubbles will be to remove, but if too hot, the balsam will burn. If too much time is consumed in removing bubbles, the balsam may begin to crystallize, in which case the job must be done over. Try not to overhang the lens too much or too often in removing the bubbles, else the cement layer will become too thin and begin to pull away from the edges. In

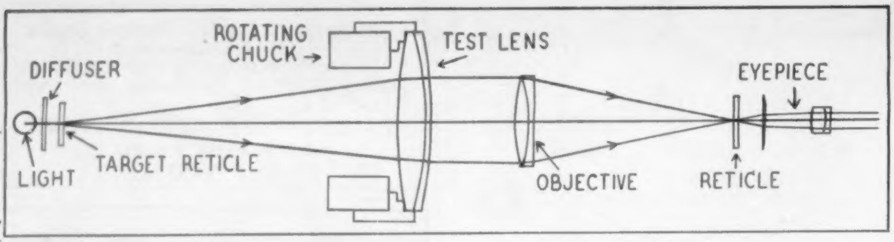


Fig. 2. The system of an optical collimator.

this case, more cement must be added, a simple task if stick balsam is used, by merely sliding away the crown and touching the stick to the exposed flint, but in the case of liquid balsam, the crown must be removed, and some more cement placed on the flint and cooked.

Centering

When all bubbles have been removed, take the lens off the hot plate and place it between the V-blocks. Holding one V-block in each hand, rotate the lens with them, so that the edges will be properly lined up. When this is done, leave the lens between the V-blocks and cover it while cooling.

If the lens is well made, such a mechanical centering should suffice and, in the absence of an optical collimator, will have to do. It is well, especially in the case of an objective, to examine the lens closely before decementing, to be sure there is no overlapping to begin with. If there is, it probably indicates collimating on an optical collimator, and that the overlapping was necessary to secure collimation. This will be very infrequently found. In any event, it is a good idea to mark the edges of both crown and flint with an indelible pencil before separating them, and to bring the marks together upon recementing.

The lens may be collimated at any future time by merely heating it to about 150° to 180° F., at which temperature the balsam will be soft enough for the lenses to be moved slightly with respect to one another.

In the event the amateur has equipment which may be improvised to provide an optical collimator, Fig. 2 shows the general plan. The lens to be collimated is mounted in a rotating chuck so as to form an image of a suitable target against a reticle. If the lens is properly collimated, the image of this target should not shift against the reticle as the lens is rotated about its mechanical axis. In the diagram, parallel light passes through the test lens; for a temporary setup, the image of the target would be as satisfactory if formed at a conjugate focal point, and the target reticle could be replaced by anything at all. The principal problem is to provide a suitable chuck. An ordinary lathe chuck is usually not closely enough aligned, as may be shown by setting it up with a lens known to be properly collimated. If one wished to take the trouble, the errors of a given chuck might be charted with a standard lens and eliminated from the measurements of the test lens.

AMERICAN ASTRONOMERS REPORT

(Continued from page 13)

dently, heavy obscuring nebulosity lies in their direction, whereas the last two stars, located in or near the Cygnus star cloud, suffer less absorption. CD Cygni, some 2,400 parsecs distant, has lost only half a magnitude through interstellar absorption.

Birkhoff's Relativity

AIDED by a theory propounded by the late Professor George D. Birkhoff, Harvard mathematician, two Mexican astronomers, L. E. Erro and Carlos Graef, director and assistant director of the National Astrophysical Observatory at Tonanzintla, have made calculations indicating that the expansion of the universe is not slowing down and that Newton's simple concepts rather than Einstein's general theory of relativity apply to measurements of infinite space.

These astronomers propose that the 200-inch telescope, by obtaining counts of galaxies to the 23rd magnitude, will furnish data for a critical test of the new theory. The limit of the 100-inch instrument is the 21st magnitude (photographic), whereas it is from magnitudes 21.5 to 23.5 that the numbers of galaxies predicted by Sr. Erro differ considerably from those proposed by previous theories. The total number of galaxies in the universe, by the new theory, comes out only 11 billion; these are found to be distributed more or less uniformly through space in a system expanding at a uniform rate.

"The all-important point in Birkhoff's formulation is his central postulate of four-dimensional flat space as the geometric frame of cosmic events," declared Sr. Erro. "To my way of thinking, this means a return to Newtonian dynamics, although the Birkhoff theory retains all the assumptions of special relativity (proposed by Einstein in 1905). Einstein's general theory is an attempt to substitute geometry for dynamics. Instead of gravitational 'forces' acting upon mass points, the concept of space curvature is introduced. Birkhoff returns to the concept of 'force' and to the implicit Newtonian postulate of flat space."

Research by Dr. Edwin P. Hubble, of Mount Wilson Observatory, has shown that if the assumption is made that the universe is in expansion in the sense predicted by Einstein-Lemaitre relativity, the red shifts seem to vary as if the rate of expansion were slowing down; that is, the velocities of recession of the more distant galaxies increase faster than in proportion to the distance from our home galaxy. The resulting time interval since the beginning of the expansion proves to be less than one billion years, less than half the age of the earth. Dr. Graef's work shows that the Birkhoff theory accounts for the observed red shifts with a universe which began expanding some two billion years ago, and which is still expanding at a uniform rate.

The observed red shifts in the spectra of the distant galaxies are interpreted by the Mexican astronomers as due in part to the true velocities of recession and in part to "cosmic forces" affecting the photons of light on their passage from the distant galaxies to the observer. There is then no need to assume that the universe has been running down.

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6166-Y	29	54	1.25
6168-Y	29	76	1.25
6169-Y	31	122	1.50
6171-Y	32	171	1.00
6173-Y*	34	65	1.00
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3010-Y	Porro	43 mms.	21 mms.	.50
3029-Y	Dove	16 mms.	65 mms.	1.25
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Planetarium Notes

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900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428

SCHEDULE: Tuesdays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m.; building closed Mondays.

STAFF: *Director,* Wagner Schlesinger. *Other lecturer:* Harry S. Everett.

April: THE SOUTHERN SKIES. A trip to the south pole shows constellations never visible from northern latitudes, as well as motions of the sun and stars never seen at home.

May: RAINBOWS AND HALOS.

BUHL PLANETARIUM

Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4800

SCHEDULE: Mondays through Saturdays, 3 and 8:30 p.m.; Sundays and holidays, 3, 4, and 8:30 p.m.

STAFF: *Director,* Arthur L. Draper. *Other lecturers*: Nicholas E. Wagman, J. Frederick Kunze.

April 7-21: EASTER AND THE STARS. The inspiring story of the Resurrection under the spring stars.
Beginning April 22: THE STARS AND YOU. The true and false in the cosmos.

FELS PLANETARIUM

20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Rittenhouse 2050

SCHEDULE: 3 and 8:30 p.m. daily; also 4 p.m. on Saturdays, Sundays, and holidays. 11 a.m. Saturdays, Children's Hour (adults admitted).

STAFF: *Director,* Roy K. Marshall. *Other lecturers:* I. M. Levitt, William L. Fisher, Armand N. Spitz, Robert W. Neathery.

April: TRIP TO THE MOON. Atomic power to fuel the rocket ship that is radar-guided to a safe landing and return makes this year's excursion better than ever.

May: TRIP TO THE MOON.

GRIFFITH PLANETARIUM

P. O. Box 9866, Los Feliz Station, Los Angeles 27, Cal., Olympia 1191

SCHEDULE: Friday and Saturday, 3 and 8:30 p.m.; Sunday at 3, 4:15, and 8:30 p.m.

STAFF: *Director,* Dinsmore Alter (on military leave). *Acting Director,* C. H. Cleminshaw. *Other lecturer:* George W. Bunton.

April: EASTER AND THE CALENDAR. How the sun and moon have given us our year of 12 months; history of the calendar; leap year; variation in the date of Easter.

May: THRU THE TELESCOPE.

HAYDEN PLANETARIUM

81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.

STAFF: *Honorary Curator,* Clyde Fisher. *Chairman and Curator,* Gordon A. Atwater. *Other lecturers:* Marian Lockwood, Robert R. Coles, Catharine E. Barry, Shirley I. Gale.

April: ATOMS, STARS AND COSMIC BOMBS. Atomic energy is the topic of the hour. Visit the planetarium in April and learn how this mysterious force permeates the universe.

May: SPRING AND SUMMER STARS.

In Focus

THIS month's back-cover picture adjoins the one reproduced last month, extending farther to the north on the moon (south is at the top).

On the accompanying identification chart this month, as will be true of future charts, all named features on the moon are indicated. In comparing the chart with the picture, it will be noted that a number of good-sized features bear no names; these in most cases are identified by selenographers by the name of a nearby feature and a letter, with capital Roman letters serving for depressed features (craters, valleys, and so on), and small Greek letters for eminences.

Spellings used follow in all cases the official International Astronomical Union publication, **Named Lunar Formations,** by Blagg and Mueller. Bibliographical data given below are taken from the British Astronomical Association publication, **Who's Who in the Moon.**

Atlas. This feature, and its companion, Hercules, were named by Riccioli, who believed the two mythical giants had human originals, both astronomers living in the 16th century B.C. On the moon, these are two ring plains, both with walls rising to over 10,000 feet; Atlas shows considerably more detail in its interior.

Bernouilli. It is uncertain for which of the two distinguished brothers, both mathematicians, this feature was named. Three sons and two grandsons of one of the brothers were also mathematicians. The name is more commonly spelled Bernoulli in American texts.

Bond. Named for G. P. Bond (another feature is named for his father, W. C. Bond), a director of Harvard Observatory and pioneer in celestial photography, this is a 12-mile crater. A cleft may be traced along its eastern side, extending over 150 miles to end east of Roemer.

Cepheus. Named by Riccioli for the mythical king of Ethiopia, who is also commemorated among the constellations.

Chacornac. A large irregular ring plain, with a cleft in its interior, possibly connected with another one which stretches toward Le Monnier.

Chevallier. A ring plain with very low walls, and difficult to see in this reproduction.

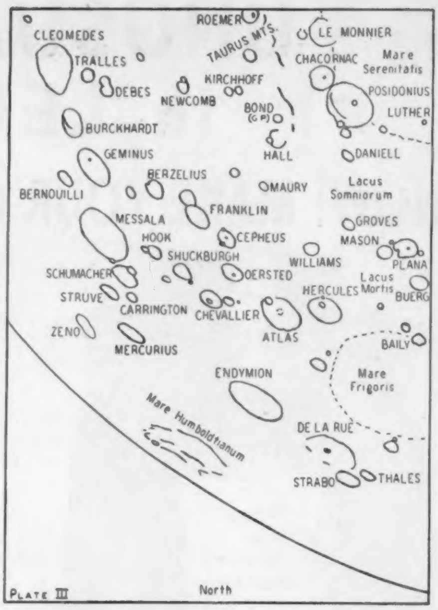
Cleomedes. A walled plain some 80 miles in diameter, with walls rising 9,000 feet on its western side, and a number of craterlets in its interior. Cleomedes was a Greek, whose treatise on astronomy is particularly valuable in that it describes work of Eratosthenes and Posidonius (also commemorated on the moon), and of others whose original accounts have been lost.

De la Rue. An indistinct plain about 65 miles across, whose walls are irregularly broken and discontinuous.

Endymion. A large ringed plain, with broken walls, and a dark, comparatively smooth interior, another of Riccioli's legendary figures in this part of the moon.

Franklin. A ring plain with massive walls and dark interior (Franklin F adjoining it on the southwest) is named for the famous American.

Groves. A deep and bright feature named for a 19th-century English lawyer



and amateur scientist. The name is correctly Grove, although the I.A.U. has perpetuated an error made by Neison on his lunar map, according to **Who's Who in the Moon.**

Hercules. See Atlas.

Lacus Mortis and **Lacus Somniorum** are the Lake of Death and the Lake of Dreams.

Mare Frigoris, Mare Humboldtianum, and **Mare Serenitatis** appear on this map. The first, the Sea of Cold, is appropriately near the north pole of the moon. Mare Humboldtianum, near the limb, is never satisfactorily observed. It was named by Maedler after Alexander von Humboldt, (1769-1859), a German naturalist, who explored some of the great South American rivers early in the 19th century. Maedler gave the name appropriately, for he considered that the Mare connects the visible and invisible hemispheres of the moon as von Humboldt's studies of meteorology and magnetism linked the terrestrial Eastern and Western hemispheres.

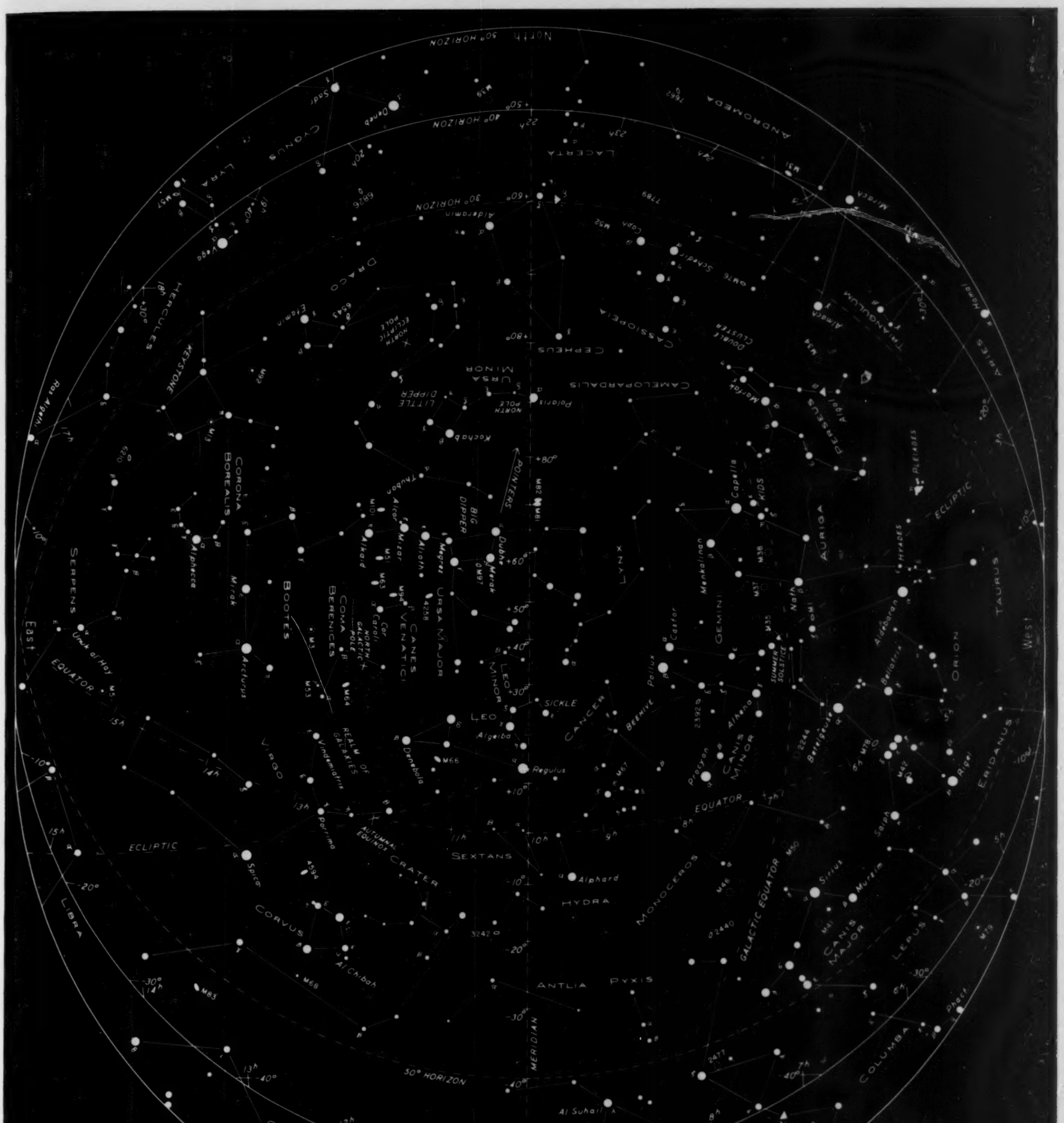
Maury. A crater about 10 miles in diameter, with Maury A the larger crater to its southwest, named for the first director of the U. S. Naval Observatory.

Mercurius. A ring plain about 25 miles in diameter, with a smooth floor and a small central mountain. Named by Riccioli after the messenger of the gods, Mercury, one of the few mythological characters represented on the moon.

Posidonius. A walled crater about 60 miles across, with a wealth of detail in and around it.

Roemer. An irregularly shaped feature standing in the Taurus highlands, with terraced walls and irregular floor, was named for the Danish astronomer who in 1675 discovered the finite velocity of light, through observation of eclipse times of Jupiter's satellites.

Struve. An irregular plain, called Mare Struve by an earlier lunar authority, is an indistinct feature, but standing on a dark region of the moon. It is named for Wilhelm Struve (1793-1864), first director of the Poulkovo Observatory, and measurer of the parallax of Vega in 1840. Another feature on the moon honors his son, Otto (1819-1905).



DEEP-SKY WONDERS

OWNERS of amateur telescopes should try the April feast. The balanced menu here printed includes two galaxies, two clusters, one globular, and a planetary. Numbers in parentheses are from Norton's **Star Atlas.**

Ursa Major. NGC 2841 (205′), $9^h\ 18^m.6$, +51° 12′; spiral. Large, dim oval, with a bright center, near the star Theta.

Canes Venatici. NGC 4244, $12^h\ 15^m$, +38° 5′; spiral, like a dim ray.

Hydra. NGC 2548 (22⁶), $8^h\ 8^m.8$, —5° 30′; a cluster of 80 stars. M68, $12^h\ 36^m.6$, —26° 27′; a globular, small and bright, under Corvus.

Cancer. M44, $8^h\ 34^m.3$, +20° 20′; cluster. The famous Beehive, or Praesepe.

Corvus. NGC 4361 (65′), $12^h\ 20^m.4$, —18° 20′. Small fuzzy oval with a star-like center.

L. S. COPELAND

CHART CORRECTION: Antlia is 10° too far north; NGC 6543, in Draco, should be at $17^h\ 58^m.6$, +66° 38′.

STARS FOR APRIL

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.